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THE HAWAIIAN PLANTERS' RECORD

Volume XXVI. JANUARY, 1922 Number 1

A monthly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

High Yield Possibilities. The cover of this issue shows a picture of some ratoon cane. The plant cane preceding this crop yielded 118 tons of cane per acre and gave 15.83 tons of sugar per acre. We are not prepared to say whether the yield of the plant crop can be repeated in this, or subsequent ratoons. A great deal will depend upon the weather of the winter months and the influence that rains may exert on the quality of the cane.

An encouraging feature about these heavy crops of cane is that the methods used are simple, clear-cut, and applicable to other areas than those at Waipio—perhaps not to entire plantations, even when favorably situated, but to areas of considerable size having similar soil conditions and water supply. Such methods so applied should result in yields approaching in some measure the yields obtained at Waipio, even though the figures actually realized there are not duplicated.

A second encouraging feature about these heavy crops is that they were obtained from unselected H 109 cane and anything that bud selection has to contribute to the industry will express itself in still higher returns.

A third encouraging feature is that the variety H 109 may not be the best variety of cane which we have today for irrigated lands. An article in this issue by J. A. Verret shows that among the new seedlings we may have canes which are constitutionally superior. These seedlings, if better to begin with, will possibly lend themselves to improvement through bud selection.

The question arises quite naturally as to what is the physical limit to the amount of cane that can be produced on an acre of land. When do we reach the limitations possessed by an acre in point of sunlight and root zone? If these prove to be the limiting factors in sugar cane production, we must work for higher yields in terms of shorter cropping periods.

In other words, if we can not produce, without undue overcrowding and consequent rotting of cane in the field, more than 118 tons of cane per acre in two years' time, we must then work for yields of this character in less than two years' growing time.

A two year cycle may prove a less economical cropping period than it is

now held to be. If we can not produce three very heavy crops in six years, we must then seek to produce four heavy crops in the same length of time.

We may find, for example, that it is better business to produce four crops of 100 tons of cane in six years (or one crop each eighteen months) than to produce three crops of 133⅓ tons in six years (or one crop each two years). The gross tonnage of cane in each case will be 400 tons per acre for the six year period, and possibly we shall be better able to control the quality of cane under eighteen month cropping cycles.

Looking ahead to yields of this type, it must, of course, be remembered that we are discussing our better irrigated lands and that even then the success of such agriculture is entirely dependent upon our ability to control insect pests and cane diseases, and that the loss of control of such factors would defeat what we may otherwise hope to accomplish. Between the industry and misfortune from pests and diseases there stand the accomplishments of our entomologists, plant pathologists, and quarantine officials. They must be given every support in the work that lies before them in preventing disaster to our plantations. We must also support the work of soil research that will determine how the heavy use of chemical fertilizers can be handled to best advantage under our one-crop agriculture.

Promising H 109 Seedlings.

1918 *Oahu Propagation.*

We report herewith the results of two harvests of a series of H 109 seedlings. The series comprises 102 varieties propagated in 1918.

The tassels from which these seedlings were obtained were colleced at Ewa Plantation and at Waipio. Numbers 1 and 2 are from Ewa tassels with no other varieties growing nearby and are therefore probably pure H 109 seedlings. Numbers 48 to 55, both inclusive, are also from Ewa tassels. In this case Lahaina cane was in bloom not far away and we have possibilities of H 109 × Lahaina crosses here. All the other seedlings are from Waipio tassels, where several other varieties were in bloom nearby, the nearest of which were D 1135, Striped Mexican. Lahaina, and some H 25.

In our work of seedling propagation, after handling many thousands of tassels, we have noted that we always get better germinations, and generally more vigorous seedlings, when we gather tassels from localities having two or more different varieties in bloom at the same time, than when we collect from the center of large fields of single varieties. This leads us to the conclusion that, when we gather tassels where several varieties are growing, the majority of the progeny obtained are crosses.

This point is rather well illusrated in the present series of seedlings. They

were obtained from a total of 885 tassels, giving 1480 germinations. Of these tassels 600 were from Ewa and 285 from Waipio.

The results obtained are shown as follows:

Lot No.	No. of Tassels	Where Obtained	Other Varieties Nearby	No. of Seedlings After First Selection
8	400	Ewa	None	2
14	200	Ewa	Lahaina *	8
9	150	Waipio	D 1135, Str. Mex.	45
16	25	Waipio	D 1135	12
18	50	Waipio	D 1135	7
2	60	Waipio	D 1135	28

* This Lahaina was on the makai side. The prevailing direction of the wind was from the H 109 towards the Lahaina.

Of the above seedlings the first two, from lot 8, are undoubtedly pure H 109. The eight from lot 14 contain some crosses, while of the remaining ninety-two the large majority are crosses between H 109 and one of the nearby varieties.

The first crop was planted on March 25, 1919, and harvested January 26, 1920 The second crop, first ratoons, was cut back for seed July, 1920, and harvested October 10–11, 1921.

In reporting these results we recognize the fact that it is not possible to determine the true value of a cane seedling with any accuracy until it has been cropped for at least five or six years, but since such a large number of these seedlings have given such uniformly high yields we feel justified in giving out at this time the results obtained. No other series of seedlings ever handled at the Station has produced such a high percentage of promising new varieties.

We are spreading these seedlings as rapidly as possible at Makiki and at Waipio, for which reason we shall not have seed for outside distribution for another year or two. At that time we shall have rather large areas for the distribution of those which continue to be high producers.

A number of these seedlings show a great resemblance to H 109. Number 49, for instance, is almost identical. It was grown from an Ewa tassel and is probably a pure H 109 seedling.

The results obtained are given below. The yields are reported from net areas. In comparing them to yields reported from irrigated plantations the amounts given should be reduced by 16% to allow for ditches and water courses.

Order of Sugar Yield in 1921 Crop	Number of Variety	Tons Cane per Acre*		Quality Ratio		Tons Sugar per Acre*	
		1920	1921	1920	1921	1920	1921
1	29	63.8	148.98	12.05	7.96	5.3	18.7
2	1	92.6	104.33	9.00	6.41	10.3	16.3
3	94	52.9	102.37	6.60	6.55	7.9	15.6
4	18	92.8	97.79	10.05	6.59	9.3	14.8
5	49	81.7	100.84	9.00	6.90	9.1	14.6
6	22	73.8	98.01	7.45	6.93	9.9	14.1
7	78	76.7	89.73	7.70	6.35	9.9	14.1
8	6	64.7	90.60	8.60	6.47	7.5	14.0
9	61	86.5	99.97	7.00	7.81	12.3	12.8
10	11	85.2	100.84	14.80	7.86	5.8	12.8
11	30	78.6	90.39	8.50	7.29	9.2	12.4
12	33	70.1	82.98	8.30	6.67	8.5	12.4
13	54	69.3	77.10	8.45	6.20	7.7	12.4
14	65	61.6	79.71	9.00	6.41	6.8	12.4
15	40	63.6	79.28	7.40	6.59	8.6	12.0
16	H 109*	56.6	75.36	7.55	6.29	7.4	12.0
17	88	59.9	78.84	6.85	6.67	8.7	11.8
18	10	77.1	143.75	9.95	12.16	7.7	11.8
19	82	52.3	75.58	7.05	6.47	7.4	11.7
20	47	68.0	72.96	9.10	6.30	7.5	11.6
21	27	62.7	84.07	12.55	7.24	5.0	11.6
22	12	71.0	90.60	9.00	7.98	7.9	11.4
23	2	81.2	80.59	11.45	7.09	7.1	11.4
24	45	54.2	72.75	10.15	6.44	5.3	11.3
25	19	54.9	81.68	7.70	7.44	7.1	11.0
26	13	65.6	73.40	6.60	6.81	9.9	10.8
27	48	66.9	70.13	7.70	6.53	8.7	10.7
28	17	68.2	71.00	10.15	6.72	6.7	10.6
29	39	61.4	69.48	9.60	6.62	6.4	10.5
30	46	66.9	72.53	10.40	6.91	6.4	10.5
31	25	55.5	84.94	9.85	8.07	5.6	10.5
32	55	62.9	83.20	9.95	8.02	6.4	10.4
33	67	61.4	67.95	7.45	6.61	8.2	10.3
34	98	49.4	70.35	7.45	6.80	6.6	10.3
35	7	86.9	88.21	13.70	8.53	6.3	10.3
36	63	63.2	71.87	10.15	6.95	6.2	10.3
37	36	55.8	71.87	8.15	7.04	6.8	10.2
38	76	59.2	68.82	7.25	6.89	8.2	10.0
39	87	56.2	70.35	8.85	7.07	6.3	10.0
40	85	42.9	65.78	6.80	6.67	6.8	9.9
41	43	62.1	71.87	12.55	7.29	4.9	9.9
42	72	43.8	70.13	10.05	7.09	4.4	9.9
43	4	84.5	81.89	9.45	8.32	8.9	9.8
44	52	73.2	58.81	6.80	6.07	11.5	9.7
45	93	59.2	67.30	8.95	7.12	6.6	9.5
46	21	65.8	76.45	8.90	8.11	7.4	9.4
47	H 109*	48.4	74.05	9.95	7.85	4.9	9.4
48	69	49.2	60.98	11.20	6.49	4.4	9.4
49	16	62.7	67.08	7.40	7.23	8.5	9.3

* These yields were not obtained under plantation conditions, and should be accepted for comparison purposes only. The juices were obtained from a small hand mill and are better than mill juices would be. A liberal discount should be made before comparing to plantation yields.

Order of Sugar Yield in 1921 Crop	Number of Variety	Tons Cane per Acre*		Quality Ratio		Tons Sugar per Acre*	
		1920	1921	1920	1921	1920	1921
50	92	48.1	70.57	7.35	7.61	6.5	9.3
51	51	49.5	64.90	10.90	6.98	5.5	9.3
52	83	49.0	62.51	7.25	6.82	6.8	9.2
53	53	55.5	57.72	8.05	6.39	6.9	9.0
54	8	58.6	60.77	11.20	6.81	5.3	8.9
55	90	55.1	59.46	8.00	6.76	6.9	8.8
56	79	38.6	63.38	7.30	7.17	5.2	8.8
57	97	59.9	57.06	8.05	6.55	7.4	8.7
58	38	58.2	76.23	8.45	8.80	6.9	8.7
59	58	78.2	60.77	8.15	7.07	9.5	8.6
60	96	50.3	52.27	8.45	6.08	6.0	8.6
61	102	67.3	52.71	6.15	6.20	11.0	8.5
62	28	83.4	76.88	11.60	9.17	7.2	8.4
63	37	66.4	76.01	12.20	9.00	6.2	8.4
64	H 109*	58.8	51.45	8.20	6.45	5.3	8.4
65	60	61.0	73.40	11.30	8.86	5.4	8.3
66	77	50.8	61.25	9.95	7.77	5.1	8.3
67	34	47.3	54.01	7.60	6.57	6.3	8.2
68	73	81.5	77.54	8.15	9.52	10.0	8.1
69	26	52.9	67.52	8.15	8.31	6.5	8.1
70	80	48.1	62.07	8.70	7.64	5.5	8.1
71	84	45.1	54.89	9.00	6.78	5.0	8.1
72	23	44.9	58.37	9.95	7.30	4.5	8.0
73	91	55.8	54.23	6.80	6.99	8.8	7.8
74	66	56.9	49.66	8.45	6.40	6.7	7.8
75	99	56.4	57.50	11.20	7.38	5.1	7.8
76	75	54.5	50.75	9.10	6.75	6.0	7.5
77	70	58.6	55.51	7.05	7.54	8.3	7.4
78	71	51.0	47.92	8.15	6.50	6.6	7.4
79	21	75.1	55.76	11.45	7.82	6.6	7.1
80	41	41.4	48.57	8.30	6.87	5.4	7.1
81	50	46.4	47.26	14.55	6.63	3.2	7.1
82	9	57.9	42.91	7.65	6.11	7.6	7.0
83	35	54.2	64.03	9.95	9.10	5.5	7.0
84	68	39.4	61.20	7.85	8.80	5.0	7.0
85	15	39.9	52.93	9.10	7.58	4.4	7.0
86	32	75.6	49.22	8.20	7.09	9.2	6.9
87	31	58.4	58.37	11.30	8.44	5.2	6.9
88	81	43.8	45.96	9.00	6.78	4.9	6.8
89	42	49.0	51.62	10.65	7.97	4.7	6.5
90	64	55.5	45.08	8.95	6.99	6.2	6.4
91	74	58.4	54.89	9.55	8.77	6.1	6.3
92	101	44.7	47.04	9.10	7.61	4.9	6.2
93	62	41.6	41.82	10.40	6.81	4.0	6.1
94	89	38.8	58.37	8.20	10.33	4.7	5.7
95	86	47.5	42.04	6.95	7.56	6.8	5.6
96	57	43.1	38.77	8.05	7.09	5.4	5.5
97	14	55.5	45.96	10.65	9.41	5.2	4.9
98	56	48.6	51.40	9.75	10.82	5.0	4.8

Order of Sugar Yield in 1921 Crop	Number of Variety	Tons Cane per Acre*		Quality Ratio		Tons Sugar per Acre*	
		1920	1921	1920	1921	1920	1921
99	100	60.3	37.24	8.15	7.96	7.4	4.7
100	3	47.5	29.62	10.90	6.52	4.4	4.5
101	44	47.9	38.55	11.75	8.70	4.1	4.4
102	95	35.7	32.89	11.05	7.69	3.2	4.3
103	59	42.7	37.90	15.00	9.42	2.9	4.0
104	20	43.1	35.72	8.00	9.52	5.4	3.8
105	5	43.8	30.71	14.35	8.71	3.1	3.5

* H 109 are outside rows.

J. A. V.

Wireworm Damage in Hamakua.

By O. H. Swezey.

The accompanying cuts were taken in one of the upper fields of the Hamakua Mill Company, near the forest line. The cane was planted in February of 1921, and the pictures were taken in the latter part of October. The thin stand of cane is chiefly due to the wireworms, they having been present at the time of planting, and having destroyed the eyes of much of the seed that was planted.

Wireworms were still present in the field at the time the photographs were taken, and could readily be detected by pulling up cane stools.

The investigations of wireworms by the entomologists in the fields at different times in the year, indicate that the most common species, *Monocrepidius exsul*, is developing at various stages all of the time; that is, larvae of various ages are to be found in the soil at whatever time of the year an investigation is made. They do not occur in distinct broods at definite times in the year. Wireworms collected in the field and cared for in the laboratory have grown to maturity in varying periods, some of them maturing to adult beetles all along during successive months, even up to a year and more. The adult beetles are attracted to lights at night. It has been noticed that at some times they are much more abundant than at others, as, for instance, once at Honokaa in the month of April.

Damage similar to that shown in the photographs was prevalent in fields of Paauhau Sugar Plantation Company, and at Honokaa Sugar Company, also last year. Much of the area planted in the spring required 10% to 50% of replanting if a full stand of cane was to be obtained. Some slight injury was found in a high field at Hawaiian Agricultural Company, Pahala, but the wireworms there were more numerous in trash than in the cane furrow. Wireworms were found very numerous in cane in Kona, but they had not caused a thin stand of cane in the field. They have not yet been found injurious in the cane

Figure 1.

Figures 1, 2 and 3. Photos taken in a mauka field of Hamakua Mill Co., showing thin stand of cane due to wireworm injury to the seed.

Figure 2.

Figure 3.

fields of the other Islands, though they are known to be present generally by the beetles being collected in the fields and forests, and also coming to lights, and the larvae are often found in the soil when digging for them, or are casually noticed when digging for other purposes. This species of wireworm being notedly predacious on grubs and other insects in the soil and under trash, it has not caused injury to plants, except to sugar cane as above, in these few restricted localities.

The larger wireworm (*Simodactylus cinnamomeus*) is found much less frequently than the above species, but in August it was found to be the most prevalent species in one of the fields at Hamakua Mill Company. The work of this wireworm is somewhat different to that of the other more common one. Besides eating an eye or two, it burrows inside and eats a good deal around near the joint so that the seed is easily broken apart at the joints. It also burrows a good deal lengthwise in the seed, with the result that the seed is completely destroyed and soon rots.

The work of this wireworm is shown in Figure 4, where one seed shows eyes eaten out and other external injuries, and a lengthwise section of a seed shows burrows of the wireworm internally. This wireworm may be distinguished from the commoner one (*Monocrepidius exsul*) by examination of the posterior end, which is shown at IV in the figure. It is pointed, instead of being broad and armed with teeth as in *Monocrepidius exsul*, which is shown in Figure 3, page 2, of the *Planters' Record*, XXIII, July, 1920.

Search for Wireworm Parasites.

F. X. Williams and C. E. Pemberton, in the Philippines and in Queensland respectively, have been searching the past few months for parasites, or other

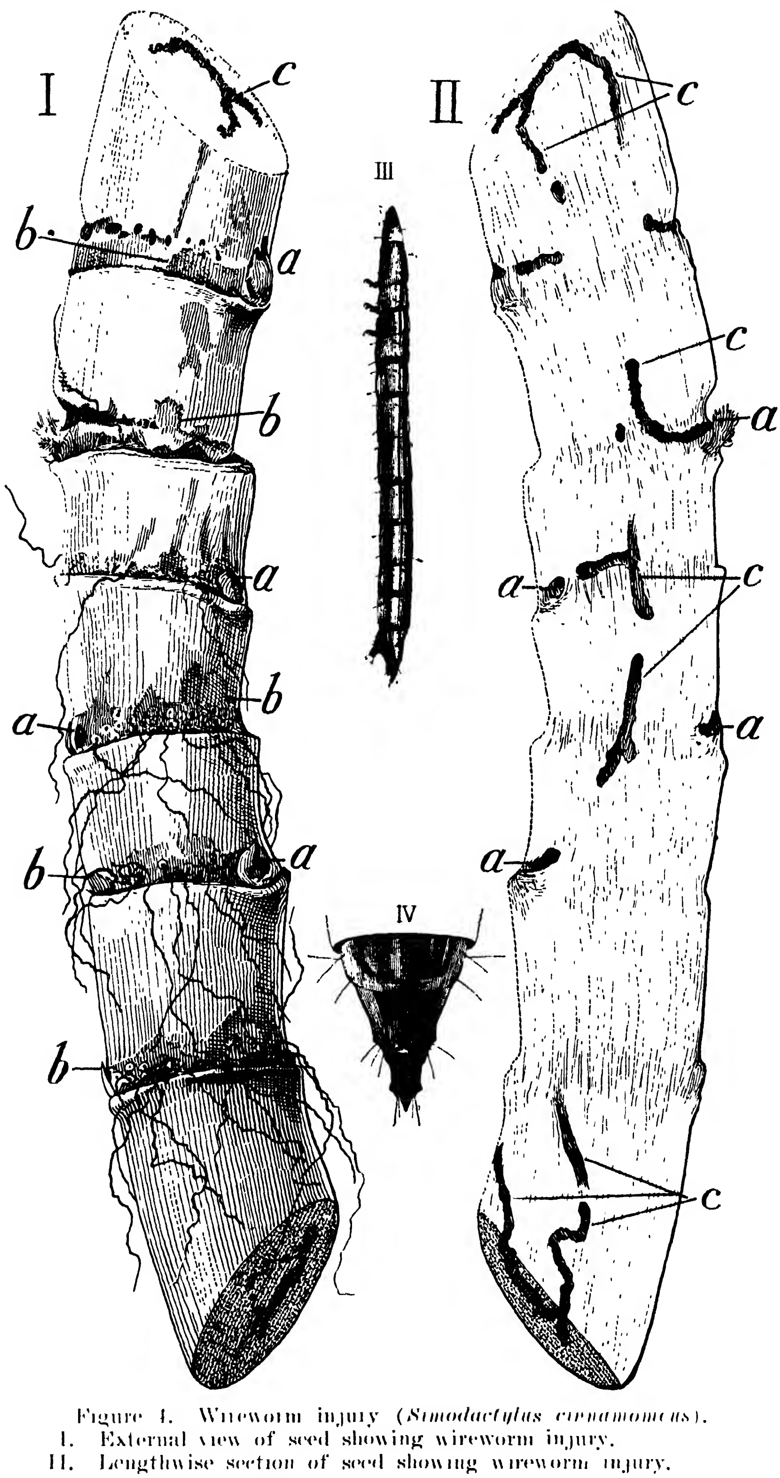

Figure 4. Wireworm injury (*Simodactylus cinnamomeus*).
I. External view of seed showing wireworm injury.
II. Lengthwise section of seed showing wireworm injury.
a. eyes eaten out.
b. Surface of rind and roots eaten away.
c. internal burrows.
III. Wireworm twice natural size.
IV. Posterior end of wireworm much enlarged.

enemies of wireworms which might seem practicable to introduce to Hawaii. Up to the present nothing of importance has been found, though Mr. Pemberton sent a mite which he found infesting wireworms in Queensland, and was occasionally fatal. As we have numerous species of mites here already in the soil and elsewhere, some beneficial and others detrimental, and as this one was not promising, it was not liberated. Mr. Pemberton also found a fungus on wireworms, but apparently of no importance. Mr. Williams has discovered a parasite on a small species of wireworm in the Philippines, but we have not yet received any of it to experiment with.

In literature, two or three records have been found of single cases where a wirewrom has been parasitized, showing that scarcely anything is known of such parasitism. One case is of a parasite on a wireworm in Vermont. The parasite was known for a long time, described in 1828, and had been collected in Maryland, Virginia, Georgia, Florida and Texas, indicating a wide distribution in the United States, but the Vermont instance is the first that was known of its parasitic habit. If this parasite should be more fully studied, it might be found to be of some importance.

Insecticides, Repellants, Etc.

Experiments with several kinds of poisons and repellants were tried at Honokaa, but none of them proved of value. Much experimenting has been done in other parts of the world, but everything that is effective is either too expensive to be applied on a field scale, or impractical for other seasons.

One of the entomologists of the United States Bureau of Entomology, experimenting with sodium cyanide, has found that properly applied in the soil at the rate of 300 pounds per acre, it kills all the wireworms. At the same time it killed all of the corn plants in the field where the experiments were made. It was found also that even at the rate of 150 pounds to the acre all of the plants were killed. It is thus found that it cannot be applied where there is a growing crop in the field. It might be possible to use this fumigant in a cane field at the time of planting. If it did not injure the seed cane and did kill the wireworms, it would thus serve to free the soil of wireworms for the time and give the eyes time to germinate and get well started before another infestation of wireworms could occur. It would be worth while trying this the next time cane is to be planted in a wireworm section. At 65 cents per pound for the sodium cyanide the expense, however, would be rather high for practical purposes.

Phosphates in Hawaiian Soils—The Combinations and Their Availability.

A Preliminary Report.

By W. T. McGeorge.

INTRODUCTION.

The role which the phosphate in Hawaiian soils plays in the nutrition of the sugar cane, while assimilated to a lesser extent than nitrogen or potash, is of considerable importance in fertilizer practices. We note from previous studies on our soils the presence of large amounts of this element, sufficient to support plant growth into an indefinite future. In spite of this fact, response is often obtained to phosphate fertilization and it is rarely omitted in the program.

Among the numerous fertilizer experiments conducted by the Station, certain areas have shown a distinct response to phosphate fertilizers, while in others no response was apparent. In order to add to our knowledge of the usual laboratory methods of studying the availability of phosphoric acid in our soils, an investigation of their relation to actual field tests has been made upon several such experimental plots.

METHODS OF ANALYSIS FOR SOIL PHOSPHATES.

General.

Methods for determining phosphates in soils may be definitely classified under four general headings: (1) Those for the determination of total P_2O_5 present; (2) extraction of soil with strong acids; (3) extraction with weak organic acids; (4) extraction with water and dilute solutions of mineral acids.

1. Methods for the determination of total P_2O_5 include fusion with a mixture of sodium and potassium carbonates, with sodium carbonate alone and decomposition with hydroflouric and sulphuric or nitric acids, involving a volatilization of silica as silica tetraflouride. While the data covering the total P_2O_5 in Hawaiian soils is meagre, the two latter methods have been found by experiment to be admirably adapted. A simpler method has been perfected in the laboratory involving fusion of the soil with sodium carbonate, extracting the completely disintegrated fusion with water, filtering and determining the P_2O_5 in the filtrate. The P_2O_5 goes in solution as sodium phosphate leaving behind the iron and alumina.

Of the total P_2O_5 determination by the above methods their value may be said to be limited yet definite. It eliminates the element of speculation that has accompanied the proposal of each new solvent as to its measure of the reserve or available P_2O_5 supply. The methods merit a more extended application to our soils. More particularly in their relation to acid soluble phosphates.

2. In strong acids we have a solvent for what Hilgard referred to as the "zeolitic reserve." In other words they should act as a measure of the permanent productive capacity of the soil. Strong nitric and hydrochloric are the acids which have received the most study, sulphuric being only lightly considered. Passing over the vast accumulation of data relative to extraction by these acids, suffice it to say that the factor of time and strength of acid vary between extremely wide limits and yield equally varying results. Hydrochloric acid gained the most favor in the old school of agricultural chemists and was finally adopted as an official method by the Association Official Agricultural Chemists. The designated strength was 1.115 Sp. Gr. and the time *exactly ten hours*. It has been generally assumed to be of value in determining the reserve supply of virgin lands. However, the recent changes instituted by the committee of the A. O. A. C. on revision of methods discredits this assumption. The facts are lacking which permit the drawing of any line of distinction between the so-called reserve and acid insoluble P_2O_5. Strong acid extraction has therefore been dropped as an official method by A. O. A. C. and the total P_2O_5 by fusion is recommended.

Hydrochloric acid of Sp. Gr. 1.115 having been the official method over such an extended period it has been extensively used on local soils. These data may be said to be of considerable comparative value. Strong nitric acid has, however, been found to yield a more complete extraction and is given preference over hydrochloric in P_2O_5 determinations at this Station on account of the slightly higher result obtained thereby. Its greater value is open to question

(3) Since it is now generally conceded that plant roots secrete no acids other than carbonic, the solvents of this class have gradually merged into class four and will therefore be treated with the weak acid solvents in use as a measure of the so-called available P_2O_5. Claims regarding the simulation of plant root activities have been practically dropped.

(4) The attempt to distinguish between the available and non-available plant food produced a bewildering array of solvents by means of which attempts have been made to measure or classify that directly available to the plant. These include 1% citric, 1% aspartic, 1% oxalic, numerous strengths of nitric and hydrochloric acid solutions such as N/200, N/100, N/5, 1%, 2%, 4%, 8%, ammonium citrate, 1% acetic acid, 1% NaOH, distilled water, carbon dioxide saturated water, each accompanied by variations in time and temperature of extraction. In addition, the numerous attempts to separate the actual soil solution by centrifugal and pressure methods should be mentioned.

Investigations on local soil problems have involved the application of several of the above methods to Hawaiian conditions. These include 1% citric acid which was developed by Dyer, on English soils, on the theory that its use was confirmed by the acidity of root sap. Aspartic acid which was proposed by Maxwell on the supposition that the organic acids of the soil were amido acids, and N/5, N/200 hydrochloric acid, N/5 nitric acid and 1% sodium hydroxide which have been shown to exercise a selective solvent action on the soil minerals. The use of distilled water has also been practiced to a limited extent and is deserving of a more comprehensive study, as after all the plant is primarily at the mercy

of the solvent power of water containing varying amounts of CO_2 and aided by certain biological activities.

The extended use of 1% citric acid as a solvent for P_2O_5 in Hawaiian soils has resulted in the accumulation of much valuable data leading to its adoption as a means of measuring the available P_2O_5.

Description of Samples.

Soil 364 is a sample of yellowish brown clay loam, virgin soil, from field 22, Experiment 9, Grove Farm, Kauai, and gave response to reverted phosphate.[1] Soils 375 and 378 are samples of a brown clay loam from Experiment 6, Grove Farm, Kauai, which gave no response to reverted phosphate applications.[2] Soil 398 is a yellow clay loam taken from Experiment 17, field 25, Kilauea Plantation, Kauai, which gave response to reverted phosphate applications. Soil 405 is a red clay loam from Experiment 2, McBryde Plantation, which gave no response to phosphates.[3] Soil 1 is a sample of brown clay loam from Experiment V, Waipio Substation, which has given no response to phosphates.[4] Soil 2 is a sample of red silty soil (manganiferous) from Experiment 6, field 45, Oahu Sugar Co., giving a distinct response.[5] Soil 3 represents the Makiki experiment plots which do not respond to phosphates.

Methods Used in This Work.

The methods used in the present investigation included determination of total phosphoric acid by decomposing the silicates with nitric and hydroflouric acids;[6] extraction with concentrated nitric and hydrochloric acids by the methods in regular use at this Station: extraction with 1% sodium hydroxide for five hours at the temperature of boiling water (1 part soil to 10 parts solvent); extraction with N/5 nitric acid for five hours at 40° C. (1 part soil to 10 parts solvent); extraction with 1% citric acid by the regular Station method. Several determinations were made using distilled water (1 part soil to 5 parts water), but on account of the high fixing power of the soil these were not extended.

The results obtained by these methods are given in the following table:

TABLE I.—SHOWING P_2O_5 AS DETERMINED BY SEVEN DIFFERENT METHODS

(Moisture free basis.)

	Soil No.	Total P_2O_5	By Con. HNO_3	By Con. HCl	By 1% NaOH	By N/5 HNO_3	By 1% Citric	By H_2O
No response to P_2O_5	375	0.45	0.32	0.28	0.125	0.00044	0.0026	0.0014
	378	0.48	0.37	0.33	0.176	0.00058	0.0031	
	405	0.42	0.36	0.33	0.136	0.00121	0.0035	
	1	0.47	0.35	0.38	0.117	0.00018	0.0034	0.0007
	3	1.13	0.70	0.50	0.566	0.1628	0.3190	
Response to P_2O_5	364	0.36	0.23	0.19	0.066	0.00035	0.0012	
	398	0.49	0.16	0.25	0.118	0.00032	0.0009	
	2	0.28	0.13	0.16	0.048	0.00043	0.0024	0.00046

PHOSPHORIC ACID SOLUBLE IN STRONG ACIDS.

In general it may be said that the soils showing no response to phosphate fertilizers are higher in total and strong acid soluble P_2O_5. Also that the ratio of strong acid soluble to total is higher. It appears from the above then that the ratio of strong acid soluble to total P_2O_5 is in a measure a function of its availability. Exceptions, however, are admitted and taken for granted.

This wide variation in the ratio of total P_2O_5 to acid soluble has been the incentive of several intensive studies of the problem. Veitch,[7] in a series of analyses of Maryland soils found a variation of 4% to 100%, of the total P_2O_5 soluble in hydrochloric acid Sp. Gr. 1.115, the average being 57.6%. Similar determinations on Virginia [8] soils showed a variation of 28% to 95% of the total to be soluble in this solvent. The data in Table I indicate less variation in Hawaiian types, being 44% to 81% (average 64%) for hydrochloric acid soluble P_2O_5 and 33% to 86% (average 64%) for nitric acid soluble P_2O_5. Fry,[9] in search of an explanation of the above, advanced two theories: (1) Either the P_2O_5 is present in the soil in compounds insoluble in acids, or (2) in such a form as to be protected from the action of the acids. The principal phosphates insoluble in acids include xenotine (yttrium phosphate), variscite (hydrated aluminum phosphate), and lazulite (hydrated iron, magneisum, aluminum phosphate). The mineralogical analyses by the Bureau of Soils have, however, never shown the presence of these minerals. But examination has disclosed the presence of acid soluble P_2O_5 enclosed in quartz grains, from which he concludes that the latter is the principal factor.

The results given in Table I apparently militate against such conclusion applying to local soils, more particularly our clay types. Less variation in ratio of acid soluble to total P_2O_5, presence of large amounts of comparatively insoluble iron, aluminum and magnesium in the acid insoluble residue; environment conducive to hydration; the lower ratio of acid soluble to total P_2O_5 in the yellow soils which are in a state of greater hydration than the red clay or brown types; and the higher P_2O_5 content of clay and fine silt as compared to the coarser particles in Hawaiian soils, all point toward the presence of highly insoluble phosphate compounds.

PHOSPHORIC ACID SOLUBLE IN DILUTE MINERAL ACIDS AND ALKALI.

One per cent sodium hydroxide and N/5 nitric acid have been extensively used as solvents for basic iron and aluminum phosphates and calcium phosphate, respectively. Stoddart [10] has shown that the basic phosphates of iron (Dufrenite $Fe\,PO_4\,Fe\,(O\,H)_3$) and aluminum (Wavelite $Al_6\,(O\,H)_6\,(P\,O_4)_4$) are 90% soluble in 1% sodium hydroxide at the temperature of boiling water. Fraps[11] found that calcium phosphate and the precipitated or normal iron and aluminum phosphates are practically 100% soluble in N/5 nitric acid at 40° C. We have here then selective solvents which, allowing for the fixative properties of the soil, should yield information regarding the forms in which the P_2O_5 exists.

Table I shows the preponderance of basic iron and aluminum over the calcium and normal iron and aluminum phosphates. This fact, however, merely confirms previous investigations [12 13] on local soils. It should be noted that the

soils giving no response to phosphate fertilization are higher in P_2O_5 soluble in these solvents.

Other than as a measure of basic iron and aluminum phosphates 1% sodium hydroxide has found little application. That is, no attempt has been made to establish a relation between results obtained by this solvent and field tests. On the other hand several of the state experiment stations have developed more or less comprehensive relations between the P_2O_5 soluble in N/5 nitric or hydrochloric acids and response to P_2O_5 fertilization. Peter and Averitt[14] at Kentucky find a close correlation between field tests and phosphoric acid soluble in N/5 nitric acid. Snyder[15] at the Minnesota Experiment Station, in studying a series of plots the soils of which ranged in N/5 nitric acid soluble P_2O_5 from .0025% to .0650%, found that all plots showing .0025 to .0083 gave a response to phosphates, while in all cases above .015% no response was obtained. Fraps[16] at the Texas Station concludes from pot experiments that soils containing less than .0020% P_2O_5 soluble in N/5 nitric acid are highly deficient, those between .002% and .010% are usually deficient. Stoddart[17] claims a response to phosphate fertilization on Wisconsin soils showing less than .015% P_2O_5 soluble in N/5 nitric acid. Kelley[18] found that Indiana soils, with few exceptions, showing less than .01% P_2O_5 soluble in N/5 hydrochloric acid respond to soluble phosphates. On later applying this solvent to Hawaiian soils only a trace of P_2O_5 soluble in N/5 hydrochloric acid was found in those soils giving a response of phosphates.

Phosphoric Acid Soluble in 1% Citric Acid.

Citric acid as a solvent for available plant food was put forth by Dyer[18] and has been extensively studied in England, where a more or less satisfactory working agreement has been established between its solvent action and field tests. It is not, however, assumed that 1% citric acid simulates any root secretion or is an absolute measure of available P_2O_5. On applying intensive tests on known Rothamsted soils, Hall[19] reached the conclusion "that no line of distinction can be drawn between available and non-available compounds in the soil. That is, no group of compounds is always available under all conditions before others are attacked." Available P_2O_5, as measured by dilute acid solvents, depends on the coefficient of solubility possessed by the acid and proportion of different phosphate compounds present. Of the solvents used in his investigations he favored 1% citric. Fraps[16] has shown that the solvent action of citric acid is similar to that of N/5 nitric acid except that the latter is a stronger solvent for calcium phosphate minerals. The precipitated phosphates of iron, calcium, and aluminum are practically completely soluble in both solvents, while the basic phosphates are practically insoluble. N/5 nitric acid yields higher results on Texas soils than 1% citric. Our results, however, confirm those of the English investigators, Hall and Amos, at Rothamsted, in that the citric extracts the more P_2O_5.

Referring to Table I, it will be noted that in all cases a higher citrate soluble P_2O_5 content is noted in the soils giving no response. Furthermore, the ratio of total to citrate soluble is higher, with the exception of the highly man-

ganiferous type, sample 2. Comment on the above is reserved for further discussion.

As a whole the data given in Table I, coupled with the investigations of other experiment stations covering the various methods of measuring the P_2O_5 needs of the soil, indicate that, regardless of method or solvent used, individual variations from the average being admitted, higher results will be obtained on those soils giving no response. It appears from the accumulated data where this problem has been extensively investigated that a working correlation is possible through a judicious choice of the most suitable solvent extensively applied and supplemented by actual field tests. Due consideration must, however, be given to the complexity of the limiting factors which influence the variations from the rule, some of which will be treated later. Data in Table I indicate 1% citric to possess advantages as a solvent admitting of its choice as such.

In the report of the Director of this Station of January 6, 1921, a suggested correlation between citrate soluble P_2O_5 and soil needs gives .004% as a point above which our soils are not apt to respond.

FACTORS INFLUENCING P_2O_5 DISSOLVED BY 1% CITRIC ACID

In view of the extended period over which citric acid has been used at this Station and the correlation suggested as a working agreement, several factors which have been heretofore ignored appeared to warrant attention. What portion of the citric acid is neutralized during the course of the extraction, and should allowance be made for this? Are Hawaiian soils capable of fixing P_2O_5 when in contact with dilute acid solvents? What is the effect of repeated extractions with citric acid? That is, what proportion of the citrate soluble P_2O_5 is dissolved by one extraction?

Acidity Neutralized.

Table II shows the acidity neutralized by the soil bases during extraction, original acidity being 1 gm. per 100 cc. for the citric extracts and 1.3 gm. per 100 cc. (approx. N/5) for the nitric acid extracts.

TABLE II.

SHOWING RELATION BETWEEN AMOUNT OF CITRIC (ORIG. 1 GM. PER 100 CC.) AND NITRIC (1.3 GM. PER 100 CC.) ACIDS NEUTRALIZED IN EXTRACTION.

	No Response to P_2O_5					Response to P_2O_5		
Soil Number	375	378	405	1	3	364	398	2
Nitric Acid gms. neutralized	0.233	0.202	0.151	0.126	0.466	0.089	0.082	0.138
% HNO_3 neutralized ...	18.0	15.5	11.2	9.3	35.2	6.85	6.45	10.5
Citric Acid gms. neutralized	0.141	0.180	0.676	0.196	0.595	0.572	0.480	0.736
% Citric neutralized	14.4	18.5	69.0	19.6	55.8	58.6	49.3	73.6

It will be noted that the activity of citric acid toward the soil bases exceeds that of nitric acid of equal strength. This offers an explanation of the greater solvent action toward phosphate compounds. Alumina, lime and manganese, especially the latter, are the primary factors in the degree of neutralization.

The relation between the degree of neutralization and P_2O_5 dissolved as given in Table III does not indicate any relationship of value.

TABLE III.

SHOWING RELATION BETWEEN CITRIC ACID NEUTRALIZED AND P_2O_5 DISSOLVED.

Soil Number	375	378	405	1	3	361	398	2
% Acid Neutralized	14.4	18.5	69.0	19.6	55.8	58.6	49.3	73.6
% Citric Sol. P_2O_5	0.0026	0.0034	0.0035	0.0032	0.297	0.0012	0.0009	0.0022

In order to throw further light upon this question, soil samples 1 and 2, representing the two extremes, were extracted with 1% citric acid in which allowance was made for that neutralized. Results obtained thereby checked with those in which no such allowance was made. It is therefore not deemed necessary to make any allowance for the acidity neutralized by the soil bases. This is probably due to the low carbonate content of Hawaiian soils in that practically none of this acid is used in neutralizing carbonates.

Successive Extractions.

Hall and Amos [20] in studying the solvent action of dilute acids on soils devoted some time to an investigation of the P_2O_5 extracted by successively attacking the soil with the solvent. In other words they desired to know what portion of the citrate soluble P_2O_5 was removed in one extraction. Fraps [16] has made a similar study on Texas soils using N/5 nitric acid.

Table IV gives the results obtained by three successive extractions with 1% citric acid on soils 1 and 2. Extractions were made by the regular method, the soil being washed twice with distilled water between extractions.

TABLE IV.

SHOWING SOLVENT ACTION OF SUCCESSIVE EXTRACTIONS WITH CITRIC ACID.

Soil No.	% Acid Neutralized	P_2O_5	SiO_2	Fe_2O_3	Al_2O_3	Mn_3O_4	CaO
1	19.6	0.0032	0.180	0.055	0.132	0.237	0.161
1	14.7	0.00017	0.063	0.027	0.026	0.062	0.043
1	10.8	0.000011	0.059	0.019	0.015	0.027	0.024
2	73.4	0.0022	0.096	0.142	0.434	1.212	0.192
2	29.4	0.00015	0.063	0.049	0.145	0.327	0.016
2	19.6	0.00003	0.055	0.038	0.087	0.172	0.024

These data suggest two possibilities: either the fixing power of the soil is very high, or the amount of citrate soluble P_2O_5 is low and completely removed in one extraction, the low subsequent extraction being due to the highly insoluble form of the residual P_2O_5. While there is ample proof that the latter is a factor of no small importance in this phenomenon, as yet we have no data on local soils covering fixation by the soil subsequent to solution, or in the process of formation of equilibrium between soil and solvent. Hall and Amos [20] found a gradual decrease in P_2O_5 with successive extractions, becoming practically constant after the fifth or sixth. It is of interest to compare these results with local soils, in which a constant figure is obtained in two or three extractions. Thus the evidence indicates that, for Hawaiian soils at least, the action of 1% citric acid is a simple solvent action removing in one extraction the most soluble phosphates in their entirety, exclusive of course of that portion absorbed by the soil in the process of equilibrium between the soil and solvent.

Adsorption from Solvent.

In order to determine the amount of P_2O_5 fixed in the presence of dilute acid solvents, extractions were made in the regular manner using solvents to which known amounts of sodium phosphate were added.

A set of preliminary determinations on soils 1, 2 and 375, using distilled water, N/5 hydrochloric acid, N/5 nitric acid, 1% citric acid and 1% sodium hydroxide, showed the following relation. The fixation from solvent decreased in the order given above. That is, it was highest in distilled water closely followed by hydrochloric and nitric acids. With citric it was considerably less and very low in the presence of 1% sodium hydroxide. Using different concentrations of P_2O_5 in the solvent it was shown that the total amount fixed by the soil increased with increase in P_2O_5 present in the solvent while the percent fixed of that present was greatest at the least concentration. For example in soil 1, N/5 hydrochloric acid being used as a solvent, where .5 gram of P_2O_5 was present, 100 grms. of soil fixed 49%, while where .1 gram was present 100 grams soil fixed 97%.

The results given in Table V show the variation and degree of adsorption in the different soils using 1% sodium hydroxide, N/5 nitric acid and 1% citric acid. On the bottom row of each sub-table are given values in which a correction is made for adsorbed P_2O_5. While this cannot be considered absolutely accurate, it more nearly approaches the true P_2O_5 solubility. In these experiments 100 grams of soil samples were weighed in duplicate and the solvents added to each, one of which aliquot contained known amounts of sodium phosphate in solution.

TABLE V.

SHOWING FIXATION FROM DILUTE SOLVENTS.

1% NaO H.

Soil No.	375	378	405	1	3	364	398	2
Gms. P_2O_5 added per liter	0.0700	0.0700	0.0700	0.0700	0.0700	0.0700	0.0700	0.0700
Gms. found per liter	0.0352	0.0360	0.0516	0.0360	0.0700	0.0296	0.0224	0.0610
Gms. fixed per 100 gms. soil	0.0348	0.0340	0.0184	0.0340	.....	0.0104	0.0476	0.0090
% fixed	50	49	26	48	..	58	68	13
% P_2O_5 in soil sol. in 1% NaoH	0.125	0.176	0.136	0.117	0.566	0.066	0.118	0.018
% P_2O_5 in soil after correction for absorption	0.187	0.262	0.171	0.168	0.566	0.104	0.198	0.054

N/5 H N O_3

Gms. P_2O_5 added per liter	0.0715	0.0715	0.0720	0.0720	0.0715	0.0715	0.0720	0.0715
Gms. found per liter	0.0118	0.0124	0.0118	0.0041	0.0356	0.0232	0.0267	0.0114
Gms. fixed per 100 gms. soil	0.0597	0.0591	0.0602	0.0676	0.0359	0.0183	0.0453	0.0601
% fixed	84	83	84	94	50	67	63	84
% P_2O_5 in soil sol. in N/5 H NO_3	0.00014	0.00058	0.00121	0.00048	0.1628	0.00038	0.00032	0.00043
N/5 H NO_3 sol. after correction	0.00081	0.00106	0.00223	0.00093	0.2142	0.00061	0.00052	0.00079

1% Citric.

Gms. P_2O_5 added per liter	0.08808	0.0659	0.0659	0.0880	0.0659	0.0659	0.0659	0.08808
Gms. found per liter	0.01898	0.0127	0.0189	0.02274	0.01650	0.0043	0.0081	0.03810
Gms. fixed per 100 gms. soil	0.06910	0.0532	0.0470	0.06534	0.0494	0.0616	0.0578	0.04998
% fixed	78	81	71	74	75	94	88	57
% P_2O_5 in soil sol. in 1% citric	0.0026	0.0034	0.0035	0.0034	0.319	0.0012	0.0009	0.0024
Citric soluble after correction	0.0046	0.0062	0.0060	0.0059	0.559	0.0023	0.0017	0.0037

The corrected values in Table V still show the relative predominance of basic phosphates over the normal calcium, iron and aluminum compounds.

In view of the ready adsorption in the presence of these solvents as shown and the increase in per cent fixed with dilution the tests were further extended, with citric acid on soils 1 and 2, using lower concentrations of P_2O_5. These results are given in Table VI and indicate a constant fixation at lower dilutions.

TABLE VI.

SHOWING RELATION BETWEEN CONCENTRATION OF P_2O_5 AND DEGREE OF FIXATION.

Soil No.	1	1	1	1	1	1	2	2	2	2	2	2
Mg. P_2O_5 added	599.7	88.1	40.0	22.0	17.7	8.2	559.7	88.1	40.0	22.0	17.7	8.2
Mg. P_2O_5 found	333.6	22.7	7.0	6.3	2.8	1.5	383.5	38.1	12.5	6.1	5.0	2.4
Mg. P_2O_5 fixed in soil	226.1	65.4	33.0	15.7	14.9	6.7	176.2	50.0	27.5	15.9	12.7	5.8
% P_2O_5 fixed	40.5	74.0	82.5	71.5	84.5	82.0	31.0	57.0	68.5	72.5	72.0	71.0

It is evident from the above that adsorption is notably less in the presence of 1% citric acid than N/5 nitric and hydrochloric acids. This, in part, accounts for the greater net action of the citric acid on Hawaiian soils and is a factor in favor of its use. Other factors must, however, be admitted as its greater solvent action is still apparent after correcting for adsorbed P_2O_5. The conclusion then is evident that in attempting to interpret the fertilizer needs of our soils from the citrate soluble P_2O_5, not only the direct or solvent action but also the reverse or adsorptive action must be considered. It does not, therefore, seem possible to establish an absolute figure to cover all the island types. Adsorption in Hawaiian soils is both high and variable. The restriction of root range and development with our variations in soil type is an important factor in the subsistence of the cane on lesser or greater amounts of available P_2O_5. These and other factors admit of variations not disclosed in the chemical analysis and not anticipated by the examination of a laboratory sample.

Let us see how this physical adsorption applies in practise. In soils 1 and 2 we have, 1 showing .0032% citrate soluble P_2O_5, on the unfertilized plots, and giving no response to P_2O_5; 2 showing .0022% citrate soluble P_2O_5, on the unfertilized plots, and giving a distinct response. To adjacent plots in soil 1, reverted phosphate was applied at the rate of 75 lbs. P_2O_5 per acre. To adjacent plots on 2, 90 lbs. P_2O_5 (from reverted phosphate) were applied with an additional comparison on other adjacent plots using 90 lbs. P_2O_5 from acid phosphate. Determinations of citrate soluble P_2O_5 in these soils before and two months after fertilization gave the following interesting results. The P_2O_5 soluble in 1% citric increased in soil 1 from .0044% to .0045%. While in soil 2 it increased from .0040% to .0065% on the reverted phosphate plots and from .0033% to .0096% on the acid phosphate plots. The conclusion from these results appears inevitable that the higher adsorption by soil 1 as shown in Tables V and VI is the principal factor involved. These data further suggest that the citrate value .0022 for soil 2 more nearly represents the true citrate soluble P_2O_5 than the value .0032 for soil 1 and illustrates the "pitfalls" these variations introduce.

NATURE OF THE ADSORPTION.

Scientists at the Bureau of Soils,[21] U. S. Department of Agriculture, have recently separated, from clay soils, large quantities of soil colloids. They have noted the effect of heat and alcohol on their adsorptive powers.

It may be of interest to submit, at this point, data covering the effect of heat and alcohol on the adsorption of P_2O_5 by our soils from citric acid solution. These results merely emphasize the role of physical adsorption by the colloids in Hawaiian soils and its relation to citrate soluble P_2O_5.

One hundred gram samples of soils 1 and 2 were heated at dull redness, in a muffle, for one hour, thus destroying both the colloids and hydrates. These samples were then extracted with citric acid in the regular manner.

The results of these analyses are given in Table VII:

TABLE VII.

SHOWING EFFECT OF DESTROYING COLLOIDS AND HYDRATES ON SOLVENT ACTION OF CITRIC ACID.

	P_2O_5	SiO_2	Fe_2O_3	Al_2O_3	Mn_3O_4	CaO	Gms. Acidity Neutralized of 1 Gm. Added
Soil No. 1—Air dry	0.0032	0.180	0.055	0.132	0.237	0.164	0.20
Soil No. 1—Heated dull red	0.0670	0.852	1.88	0.853	0.130	0.210	0.45
Soil No. 2—Air dry	0.0022	0.090	0.142	0.134	1.212	0.192	0.71
Soil No. 2—Heated dull red	0.0678	0.746	1.53	0.942	0.83	0.260	0.59

These data clearly show the predominating influence of physical factors in the adsorption of P_2O_5 from 1% citric acid when this acid is used as a solvent. The acidity neutralized during extraction and the increased solution of bases in the heated soil indicate the minor role of chemical factors. For example, precipitation as insoluble salts in the presence of the solvent It is of interest to note the greater solution of iron, alumina, and P_2O_5 in the heated samples proving the presence of the hydrated phosphates of these elements and their conversion to more soluble form by destroying the hydrate.

In view of this role of the colloids in inhibiting the complete solution of citrate soluble P_2O_5, what effect would the presence of substances, in the citric acid solution, which in themselves would lower the adsorptive power of the colloids, have on the adsorption of P_2O_5 by the soil from 1% citric acid? Theoretically the presence of alcohol in the citric acid should lower this adsorption. With this in mind 1% citric acid in solution of varying amounts of water and ethyl alcohol was used as a solvent on soil 1 with the results given in Table VIII.

TABLE VIII.

SHOWING FIXATION OF P_2O_5 FROM 1% CITRIC ACID IN PRESENCE OF ALCOHOL.

Per cent alcohol	50	25	10	5	0
P_2O_5 mgm. added	187.5	160.5	147.2	65.4	88.0
P_2O_5 mgm. found	63.4	106.7	113.2	23.0	22.7
P_2O_5 mgm. fixed	124.1	53.8	34.0	42.4	65.3
% P_2O_5 fixed	66	33	23	65	74
% citrate sol. in soil	0.0007	0.0010	0.0010	0.00075	0.0032

The higher apparent adsorption with 50% and 25% alcoholic citric acid is probably due to the low solubility of phosphate in alcohol, in other words, precipitation. It will be noted that in the presence of 10% alcohol the adsorption is at a minimum and that while the tendency is in the "right direction" the practical elimination of fixation in analysis does not appear probable. The figures given in the bottom row in Table VIII show that while fixation is lowered in the presence of alcohol the solvent action of the citric acid is inhibited.

MORE COMPLETE COMPOSITION OF SOIL EXTRACTS.

In order to further add to our knowledge of the action of these dilute solvents on our soils analysis of the extracts was extended to include silica, iron, alumina, manganese, lime and magnesia. The results are given in the following table:

TABLE IX.

SHOWING RELATIVE COMPOSITION OF DILUTE SOLVENT EXTRACTS.

Soil No.	Soil Color.	Gms. Acidity Neutralized.	P_2O_5.	SiO_2.	Fe_2O_3.	Al_2O_3.	Mn_3O_4.	CaO.	MgO.	H_2O.	
	1% Citric Acid.										
375	Dark brown	.141	.0024	.145	.208	.195	.833	.319	.091	4.58	No response
378	Dark brown	.180	.0032	.095	159	.290	1.064	.257	.088	4.67	
405	Red	.676	.0033	.105	.239	.213	.599	.207	.050	4.79	
1	Brown	.20	.0030	.180	.055	.132	.237	.164	..	6.00	
3	Greyish black	.585	.297	1.236	.626	.683	.066	1.116	.229	7.00	
364	Yellowish brown ...	.572	.0012	.016	.131	.134	.013	.050	.011	7.31	Response
398	Yellow	.480	.0009	.019	.152	.092	.005	.048	.011	5.02	
2	Dark red	.736	.0020	.090	.142	.434	1.212	.192	...	8.00	
	N/5 HNO_3										
375	Dark brown	.233	.00077	.134	.038	.465	.365	.341	Not determined	4.58	No response
378	Dark brown	.202	.00100	.117	.032	.625	.248	.308		4.67	
405	Red	.151	.00200	.1[illegible]	.038	.942	.026	.311		4.79	
1	Brown	.126	.00087	.239	.058	.286	.046	.237		6.00	
3	Greyish black	466	.22710	.633	.090	1.151	.099	.313		7.00	
364	Yellowish brown ...	.089	.00058	.012	.052	.317	.020	.059		7.31	Response
398	Yellow	.082	.00049	.008	.126	.287	.250	.065		5.02	
2	Dark red	.138	.00074	.199	.056	.66[illegible]	.222	.270		8.00	
	1% Sodium Hydroxide.										
375	Dark brown	...	.178	.190	.12	1.291	None	Trace	...	4.58	No response
378	Dark brown	...	.250	.164	.09	1.092			...	4.67	
405	Red	...	.163	.570	.09	1.121			...	4.79	
1	Brown	...	.165	.724	.07	1.540			...	6.00	
3	Greyish black	...	.526	.350	.06	.824			...	7.00	
364	Yellowish brown ...	...	.096	.056	.54	.979			...	7.31	Response
398	Yellow	...	.188	.100	.24	1.068			...	5.02	
2	Dark red	...	.050	.524	.16	.646			...	8.00	

The value of 1% sodium hydroxide as a solvent for iron and aluminum phosphates is clearly indicated by the absence of lime in solution. Also that of N/5 nitric acid for the calcium phosphates by the larger amounts of this element in proportion to iron and aluminum soluble in this solvent. While the analyses do not absolutely prove such to be the case, they, however, strongly indicate the presence of aluminum phosphate in excess of either that of iron or calcium. The low solubility of iron as compared to aluminum in N/5 nitric acid is especially noted. On the other hand the greater solvent action of 1% citric acid upon iron and the lesser solvent action on alumina and lime indicate that the higher P_2O_5 figure obtained with citric acid may be due in part to a greater solution of iron phosphate than when N/5 nitric acid is used.

While calcium phosphate is more soluble in the soil solution than either iron or aluminum phosphates their availability is closely related. Pot experiments [12] on Hawaiian soils have shown the distinct response obtained on adding normal iron and aluminum phosphates to Hawaiian soils to be practically equal to that obtained on using acid phosphate. It is therefore evident that the higher figure obtained with 1% citric acid represents the phosphate compounds most available.

In comparing the composition of the extracts from those soils giving no response to P_2O_5 and those giving a response, the wide variation in iron, aluminum and manganese is noted. There is no apparent relation between these elements and the availability of P_2O_5. It is, however, significant that basic iron phosphate is higher in those soils giving no response.

On the other hand in silica, lime and magnesia we note a relationship of no small importance. The only variation in relative silica, lime, magnesia to available P_2O_5 is that of soil 2, a highly manganiferous type, which type usually shows a high solubility of basic constituents in dilute solvents.

It has generally been assumed that the presence of lime aids in the reversion of soluble phosphates, such as acid phosphate, to the less soluble calcium salt in the soil. That it functions as such in Hawaiian soils is probably true but still open to question. Pot experiments [12] on our red ferruginous clays have shown indications of its functioning to a limited extent as such. Furthermore, the sandy type of soil in and about Honolulu (Station soil), which may be classified as a highly calcareous type, is very high in calcium phosphate content and does not respond to phosphate fertilization. In view of the analytical results given in Table IX it is evident that the presence of more soluble forms of lime is a factor in the availability. For further information let us refer to Bul. 45, A & C series this Station, and note the results obtained in the Survey of (Island) Hawaii Soils. In the Hilo-Hamakua district, citrate soluble lime is low (soils very acid). Citrate soluble P_2O_5 is also low in spite of high total P_2O_5. In the Kau district the citrate soluble P_2O_5 is the highest on the island, likewise lime is high and soils of low acidity or alkaline. Similar relations exist in the Kohala district except that the lime content is not so high as in Kau, while in the Hilo-Puna district we note also a high citrate soluble P_2O_5 with fairly high lime.

Wheeler [23] found iron and aluminum phosphates, with lime, to be better than acid phosphate, basic slag and floats. Similar results have been obtained in Australia.[24] Whitson [25] and Stoddart [17] found a low comparative P_2O_5 con-

tent in acid soils. The data submitted in Bul. 45 indicate low available P_2O_5 to be associated with soil acidity and warrants further study.

While the literature covering the relation of silica or silicates to the availability or assimilation of P_2O_5 is limited, Hall and Morrison[26] have published a very comprehensive report of investigations along this line at Rothamsted, where sodium silicate has been applied as a manure on experimental plots over long periods of time, and shows well marked results. It was noted thereon that barley grown on those plots to which silica was added closely resembled that on the phosphate plots, especially at the ripening off stage. This then led to a study of the relation between the function of phosphates and silica with the following conclusions: Although silica cannot replace P_2O_5, or even economize and make more effective a restricted supply already within the plant, it will stimulate the plant to assimilate a greater amount of P_2O_5 should that be obtainable from the medium in which the plant is growing. Hence, when applied to a silica plant, and sugar cane may be rightly placed in this class, on a soil impoverished in P_2O_5 it has the same effect as a direct application of P_2O_5. They also showed by experiment that silica has little or no effect on the solubility of P_2O_5 in citric acid except on those plots receiving P_2O_5 as a manure. From which they claim that soluble silica in the soil has no action on soil P_2O_5.

With the limited information available in Table IX, it is impracticable to comment upon the local application of the above contentions of Hall and Morrison. It is hoped, however, that a further study of this problem will throw some light upon it. The higher silica content soluble in N/5 nitric, 1% citric and 1% sodium hydroxide, uniformly accompanies no response to P_2O_5 in all the soils investigated. The relation of soluble silicates to the availability of P_2O_5 to sugar cane in our Island soils can only be determined by culture experiments.

SUMMARY.

Burgess[22] has given the comparative P_2O_5 content (strong hydrochloric acid digestion) of Hawaiian and mainland soils as .35% and .16%, respectively. In view of the higher percent of total dissolved from mainland soils the variation in total P_2O_5 is probably higher than this figure. While on mainland soils .30% is considered a very high P_2O_5 content, and soils containing as low as .05 to .10% often give no response to phosphate fertilization, in attempting to make recommendations from comparative analyses reservation has always been made for any high iron and alumina content. The wide variation in P_2O_5 dissolved from mainland soils by strong acids is due principally to their high silica content, as silicon dioxide, which under certain conditions protects a varying amount of P_2O_5 from the solvent action of the acid. In Hawaiian soils, silica is present, in major part, as silicates, more easily broken down in acid digestion. This with other factors brought out in this investigation indicates the insoluble P_2O_5 to be present as highly insoluble compounds. On this basis the relation of the total P_2O_5 in Hawaiian soils to that soluble in strong acids, gives a certain amount of indication of its solubility. Without the total P_2O_5 content for comparison these results are of little value except where a deficiency is apparent.

The principal phosphate compounds present are the basic (hydrated) phos-

phates of aluminum and iron. Results indicate the former to be in excess. Lesser amounts of normal phosphates of aluminum, iron, calcium, and possibly magnesium are present. In these more soluble forms as measured by dilute acids, aluminum again appears to be in excess of iron with the calcium phosphate least.

We have, in dilute citric, nitric, and hydrochloric acids empirical solvents for the normal phosphates of iron, aluminum and calcium. The strength of solvent is more or less arbitrary. Within certain limits the strength and method of extraction once chosen, however, should be maintained. Extensive investigations covering the use of these solvents has resulted in the empirical adoption of 1% citric, N/5 nitric, and N/5 hydrochloric as the most desirable solvents. We note in literature some investigators favoring the use of one or both of the mineral acids while others favor the use of citric as showing a more comprehensive relation to field tests

The choice of a weak solvent depends more or less upon such factors as adsorption, soil colloids, nature of the soil bases, etc. For Hawaiian soils 1% citric acid as a solvent is influenced less by the adsorptive action of the soil colloids and exercises a greater solvent action than the mineral acids of N/5 strength. Also, it is not necessary to allow for the citric acid neutralized during the extraction and in addition successive extractions indicate a more or less constant value after one extraction That is, the P_2O_5 dissolved after one extraction is so small as to be negligible.

Is it then practicable to establish a working agreement between the citrate soluble P_2O_5 in Hawaiian soils and their fertilizer needs, as applied to areas devoted to sugar cane culture? To say that such is possible over such extended areas as the mainland of the United States, or even one state, the soils of which are planted to diversified crops, is admittedly absurd. We are concerned in our case with only one crop, sugar cane, which is admittedly not a heavy "phosphate feeder." Maxwell,[27] in a study of thirteen varieties of cane grown on the same soil, under control conditions and carefully analyzed, found that the P_2O_5 removed from the soil varied from 170 to 290 lbs. per acre * These results indicate either a variation in the phosphate needs or the feeding power of these varieties. The lands devoted to sugar cane culture embody only the lower elevations, involving thereby less variation in soil type. The extent of this variation has not been definitely determined. The two essential factors, then, that stand out are a knowledge of the feeding power or P_2O_5 needs of the standard cane varieties of the Islands and a more systematic classification of the soil types devoted to sugar cane culture.

One per cent citric acid has been most extensively used at the Rothamsted Station in England, where Dyer[18] established .01% (citrate soluble P_2O_5) as the limit below which a phosphate need was indicated. Hall and Plymen[19] on applying this to experiment plots at this same station obtained a response to P_2O_5 fertilization on four plots showing .0087, .01, .013 and .021%. On a fifth they obtained no response when .0082% citrate soluble P_2O_5 was shown.** Hall,

* These amounts appear high, due possibly to the cane having been grown at Makiki plots, where soil is extremely rich in phosphoric acid. The figures are introduced to illustrate existing variation.

** Total P_2O_5 on these soils approx. 0.1%.

nevertheless, admitted a working agreement of considerable value, suggesting .02% as a minimum instead of the .01% of Dyer. It is interesting to compare the high total P_2O_5 content of Hawaiian soils and the low citrate figure, .004%, which general observations have indicated as the approximate minimum for our soils.

In the laboratory we find that due consideration must be allowed for the reverse or adsorptive action as well as the solvent action of 1% citric acid during the course of the analysis. Also that there appears to be a relation between the calcium and soluble silicate and the assimilation of P_2O_5. These and other factors entering into the chemical examination of the soil with 1% citric acid do not allow of a thoroughly sound scientific basis on which to establish the relation between the P_2O_5 dissolved by this solvent and the P_2O_5 needs of the soil. Yet it does not preclude the possibility of a practical working agreement between the P_2O_5 needs of known varieties of cane on similar soil types when backed up by field observations.

The chemical examination of a laboratory soil sample, regardless of the nature of this examination, is more or less empirical in spite of the soundness of its scientific basis. Variation in soil type and plants to be cropped thereon must need be considered. We know, for example, that plants thrive on less available phosphate in a sandy soil than in a clay, due to their greater root range in the former.

All facts considered, the reduction of probabilities to a minimum must involve a knowledge where possible of the previous performances of the field in question; otherwise the overindulgence in probabilities is inevitable where chemical analysis only is at hand on which to base recommendations. The proper balance between fertilizer, crop and soil which is essential to optimum growing conditions cannot be determined through a knowledge of one factor alone.

FOOTNOTES.

1. H. S. P. A. Exp. Sta. Record XXIII, p. 212.
2. H. S. P. A. Exp. Sta. Record XXI, p. 84.
3. H. S. P. A. Exp. Sta. Record XX, p. 333.
4. H. S. P. A. Exp. Sta. Record XXV, p. 20.
5. H. S. P. A. Exp. Sta. Record XXIV, p. 58.
6. U. S. Geological Survey Bul. 700.
7. Md. Exp. Sta. Bul. 70.
8. Va. Exp. Sta. Bul. 200.
9. Jour. Ind. Eng. Chem. V, p. 664.
10. Wisc. Exp. Sta. Res. Bul. 2.
11. Jour. Am. Chem. Soc. XXVIII, p. 823.
12. Haw. Agric. Exp. Sta. Bul. 41.
13. Jour. Ind. Eng. Chem. II, p. 277.
14. Ky. Exp. Sta. Bul. 126.
15. Minn. Exp. Sta. Bul. 102.
16. Texas Exp. Sta. Bul. 126.
17. Jour. Ind. Eng. Chem. I, p. 69.
18. Jour. Chem. Soc. LXV, p. 115.
19. Jour. Chem. Soc. LXXXI, p. 117.
20. Jour. Chem. Soc. LXXXIX, p. 205.
21. Jour. Ind. Eng. Chem. XIII, p. 527.

22. H. S. P. A. Exp. Sta. A & C Bul. 45.
23. Jour. Ind. Eng. Chem. II, p. 133.
24. Exp. Sta. Record XL, p. 24.
25. Jour. Am. Chem. Soc. XXIX, p. 757.
26. Proc. of Royal Society B. LXXVII, p. 455.
27. H. S. P. A. Exp. Sta. A & C Buls. 5 and 6.

Collapsed Boiler Tubes.*

An instance of the peculiarities attending boiler accidents came to the author's attention last year when he had occasion to make an internal inspection of a horizontal return tubular boiler, which was found showing evidence that the water in the boiler had at some time been allowed to reach a low level. Generally speaking, to allow the water in a steam boiler to fall below a predetermined safe working level causes the exposed tube ends and seams to leak, and it is not unusual to find it possible to have the boiler placed again in a serviceable condition by expanding the tube ends and caulking the seams to make them tight.

The boiler mentioned in this article was supplied with feed water by direct connection with the pressure main. The operator had various duties to perform, requiring periodic absence from the steam plant, and due to the practically unvarying load on the boiler, found it possible to adjust the feed water valve and the oil burner to maintain a fairly constant water level and steam pressure. During a temporary absence of the operator, the water in the main was shut off without previous warning, due to necessary repair to the water supply system, and when the attendant returned to the boiler he found no water in sight in the gauge glass, and a test of the feed connection showed no water pressure in the supply pipe.

The boiler was shut down and it was found that the water had fallen to a point about 18 inches above the bottom of the shell. A great many of the tubes were therefore found not covered with water and, of course, leaked considerably, the rear head seam also requiring to be caulked tight. Up to this point the proceeding is what may be termed "regular," but when 17 of the tubes were found collapsed, some partially and others totally, a condition arose that was "irregular," as it is not common to find tubes collapsed in cases of low water.

The collapse in this instance appears to be attributable to the fact that considerable soot had collected in some of the tubes and caught fire, causing overheating of the metal and reducing its power of resistance to a point where collapse was possible. Many of the tubes were badly buckled, 40 requiring renewal. These, together with the 17 that collapsed, represent a repair cost of considerable size, the tubes being 3 inches in diameter and 16 feet long. The

* From Powor Plant Engineering.

accompanying photograph will prove interesting in showing the extent of collapse and to what degree some of the tubes were buckled.

In many accidents there are revealed ways and means by which their prevention would be effected, and in this case, if the feed water had been supplied by a pump in conjunction with a storage tank, it is quite possible that the condition brought about would not have occurred.

Collapsed and buckled tubes resulting from low water.

Prolonged absence of an operator from an active boiler is to be looked on with much disfavor, not being conducive to its safe operation and contrary to the principle of "Safety First." In some states and municipalities the length of time which a boiler may be left without an attendant is fixed by statutes and ordinances, as it is recognized that a boiler under steam pressure represents a potential hazard. [W. E. S.]

The Origin of New Canes by Bud Variation.

By C. A. Barber.

This is another article pertaining to the general subject of improving sugar cane through selection. It was published originally in the Agricultural Journal

of India and was reprinted by the International Sugar Journal in 1907. All of this early work is important for the bearing that it has upon the project of bud selection in its present stage of development. Observations covering color variations in cane go back to the days of Charles Darwin.

Other papers of this character will be published from time to time in an attempt to make a review of this work up to the present time, when it attains much commercial significance when reduced to the working basis of selecting cane stools based upon their size, uniformity, and number of sticks.

One of the most striking facts connected with sugar cane cultivation is the enormous number of varieties which, though easily separable, have the greatest botanical similarity. It is frequently possible to distinguish two varieties without being able to put down clearly wherein the difference between them exists. The difference may be in the form of the joint, in the tinge of color, in the habit of the plant in the field, in its thickness or height, in the richness of the juice expressed. Again, with no external differences at all, there may be such a difference in constitution that, whereas one cane grows clean and healthy and yields a certain crop, the other is swept out of the fields by disease.

Even after prolonged study it is difficult to decide how all these varieties have arisen. There is no doubt as to the ancient character of sugar cane cultivation. While it is probable that the cane was first cultivated in a certain Asiatic region, yet nowhere can we lay our hands on a Saccharum, now wild, which presents any probability of being the progenitor of the cultivated forms. The matter is not rendered easier by observing how peculiarly susceptible the sugar cane is to any change in its environment. We cannot tell beforehand in what direction changes are likely to occur, but certain it is that if two canes are taken from one part of the country to another, their characters under the new condition differ, whether in color, form, or sugar-making properties. The pet cane of one region quickly assumes a very second rate character in another, being left behind by a cane which could in no way be considered its rival in the land of its origin. Some improve in their juice and others deteriorate, some change their color and others do not, while some really good canes dwindle to the size of the local "reeds" which are everywhere to be found where sugar cane has long been cultivated.

With these obvious facts before us, there is an entire absence of a good connected series of observations, and we have to confess that we know next to nothing as to the way in which the countless varieties of sugar cane at the present day have arisen.

From this point of view a study of the striped canes, or those which have two main colors alternating in their stems, appears most likely to lead to interesting results. And the first subject for investigation is to try to find out how these varieties have arisen.

In all likelihood the yellow or green canes were the first obtained and cultivated, and the others arose as subsequent varieties. The assumption of a red color by the rind of plants under cultivation is by no means an uncommon phenomenon. The striped canes would probably be the last formed, and there is

some reason for supposing that each striped cane has for its parents two canes, a red and a yellow one. Such striped canes may have arisen in several ways. Firstly by seminal crossing. While seedling canes appear to be very rare in India, they are not at all uncommon in certain tropical islands; and it is fair to assume that in past times this seminal reproduction was much commoner than it is at present. The practice of growing canes of different varieties in the same field is probably very ancient, and we have a ready means by which the striped canes may have originated. That they have arisen late, among canes already cultivated, appears to be also probable from the fact that the striped canes as a whole are ones of good character from the milling point of view, and while there are numerous yellow and less frequently red canes of a reed-like primitive nature, such canes are hardly ever striped. But there is just sufficient evidence to render it possible that these striped canes have arisen from the apposition of two canes of different colors by natural grafting, and it is possible that some at least of the striped canes are in reality graft-hybrids. The general absence of grafts among monocotyledons renders this less likely but not impossible, and exhaustive experiments are called for to determine whether we may not by this method hope to raise new varieties. But the strongest argument in favor of the origin of striped canes from parents of two different colors is the not infrequent reversion of these varieties into canes of single colors. Such "sports" are by no means infrequent and form the subject of the present paper.

It is a matter of common knowledge among the Godavari ryots that in a field of Namalu (striped red and yellow) canes, sooner or later the number of Keli (yellow) canes increases. And when we take the Namalu and Keli canes and compare them from a botanical and chemical standpoint, it is difficult to find any real difference between them excepting in their color. There is then a strong presumption that the Keli is a natural sport from the Namalu. And it may be at once asserted that the tendency in the striped canes is always to produce yellow rather than red sports, a fact which seems natural when we consider that the yellow canes are probably the older and nearer to the original cane of the primitive cultivation.

The following canes have been noted in the short life of the Samalkota Sugar Station in the Godavari district. The cane known there as the "Striped Mauritius" has been seen frequently to sport into green canes and less often into canes of a pure red. There are now good plots of all these canes, and they have been submitted to analysis for two years. There is no doubt that the three canes have sufficient differences, besides their color, in the richness of their juice and in their habit of growth, to constitute well-marked varieties in the ordinary sense of the term. It is quite in accord with what has been suggested above, that the green is the hardier, bunches more readily, and has inferior juice; that the red cane, on the other hand, is little inferior, if indeed it is not superior, to the striped, which otherwise holds an intermediate position between the other two.

The thick striped cane, called on the farm the "Dark Striped Mauritius," has also been identified as the parent of the yellow "Ivory Mauritius," but no red cane has yet been obtained from it. The long striped cane obtained from various parts of South India, called by some the "Striped Singapore," has sported into both red and yellow, but the characters of these have not yet been deter-

mined. Finally, the striped cane growing in Abraham Paudither's garden at Tanjore (which cane may be identical with the last named) has given rise to a new ashy cane which appears to be well worth cultivating.

This mode of origin of new cane varieties has been termed "Bud-variation." After observing the facts described above on the farm at Samalkota three years ago, my attention was drawn to an article in the West Indian Agricultural Bulletin, where the subject was exhaustively dealt with. No analyses were, however, published of the different canes arising from bud-variation. As in the cases noted above, it was always a striped cane which showed this phenomenon in the West Indies, Louisiana, and Mauritius. It is worthy of note that this bud-variation does not consist in certain buds growing out to form new canes orf one color, but isolated buds show variability and give rise to shoots of different colors, sometimes, indeed, to a shoot whose base is striped, but which becomes yellow in its upper part. The idea that a bud in the red part of a striped cane gives rise to a red cane, whereas one in the yellow part produces a yellow, is apparently not correct. The canes thus arising appear to retain their characters, and have remained constant for three or four years already.

Now this fact, that the striped canes have alone been observed to "sport," may be explained in two ways. On the one hand they may be true hybrids which have arisen from the crossing of the two one-colored canes, and consequently may have a greater tendency to vary than the one-colored canes. But on the other hand the frequency of the phenomenon in striped canes may be due to the fact that, while such changes in color are very readily seen in them, they would require very careful observation in the case of ordinary canes. And I think that the latter is more likely to be the explanation. If such is the case, it behooves us to study our fields with much greater care than heretofore. Whenever, in a uniform field, canes appear which show any marked differences from the rest, they should be carefully segregated, cultivated, and analyzed. A certain amount of work has been done in this direction at Samalkota, but the results thus far obtained have not been satisfactory. Chance differences which have been observed have not been maintained. But this is no reason why the subject should be dropped, and observations will be continued as opportunity offers.

With reference to the Striped Mauritius and its "Sports," the more important figures in the two years' analyses have been reproduced in the table. The Green Sports may be classed as a cane distinctly inferior to the other two, whereas the Ivory appears to be distinctly better than the Dark Striped. The Red Sports during the first year showed such good results that it was thought that a new cane of great value had been discovered. It was accordingly named the "Gillman," after the Collector of Vizianagram, through whose energy and forethought these Mauritius canes had been introduced into Madras. These canes and others obtained in the future will be multiplied, and, in due course, valued and added to those on the farm, or rejected, according as they turn out.

ANALYSIS OF STRIPED CANES AND SPORTS IN THE GOVERNMENT SUGAR CANE FARM, SAMALKOTA.

Varieties		Juice: Corr. Brix	Juice: Per Cent Sucrose	Juice: C. P.	Juice: Per Cent Glucose	Bagasse: Per Cent Obtained by Crushing
Striped Mauritius,	1904-05..	20.44	19.33	94.57	0.30	37.23
" "	1905-06..	21.31	19.94	93.57	0.67	37.53
Green Sports,	1904-05..	20.29	18.66	91.96	0.60	33.92
" "	1905-06..	18.57	16.61	99.45	0.93	34.79
Red Sports,	1904-05..	21.35	20.23	94.75	0.30	39.67
" "	1905-06..	20.16	18.88	93.65	0.67	34.48
Dark Striped Mauritius,	1904-05..	17.06	13.98	81.94	1.54	36.87
" " "	1905-06..	16.98	13.95	82.15	1.95	36.86
Ivory Mauritius,	1904-05..	18.67	16.11	86.29	0.75	38.96
" "	1905-06..	17.87	15.37	86.01	1.34	40.41

The Sugar Industry in Java.*

As seen by the Indian Sugar Committee.

It is a curious fact that, although masses of detail are published every year about the Java sugar industry, there are few countries about which more contradictory statements are served up by journals dealing with sugar matters. And these statements refer to the most varying factors, such as the relative fertility of the soil, the relations between the planters, the Government and the land-owners, and even the production of sugar in any one year. It may be that this confusion is partly due to the presentation of the information in the Dutch language, which has its own peculiar difficulties to the English or American reader; but, whatever the cause may be, any first-hand description of the industry of an authoritative nature is likely to be welcome. We have therefore thought it worth while to place before our readers a summary of some of the points in the second chapter of the Report of the Indian Sugar Committee, which contains a careful account of their observations during a month's stay in the island. As the Dutch Government and the planting community appear to have given them every facility for forming just views as to the state of affairs in the sugar industry, we may with some show of reason regard this account as more or less of an authoritative nature.

It may be well at the outset to explain that the sugar factory and plantation in Java are under one head, and that the mill and the cane fields work in complete accord. Further, whatever may have been the case in the past, the sugar

* The International Sugar Journal, September, 1921.

industry is entirely self-contained as regards all investigations for the improvement of cultivation and manufacture. The entire cost of all the complicated machinery for carrying out these investigations is borne by the industry, by means of voluntary cesses on acreage of cane, amounting at the time when the report was written to about 6s. per acre planted; and the expenditure for research alone during 1919–20 reached the sum of 1,200,000 guilders or £105,000. No help was obtained from Government, whose experimental stations are mainly, if not entirely, concerned with crops other than sugar cane.

It is generally recognized that the success of the Java sugar industry during recent years has been mainly due to the intricate organization for the solution of the many difficulties which occur in all cane-growing countries, and of which Java has had its full share. This organization will accordingly be dealt with in this note in some detail, especially as it is entirely built up by an industry as contrasted with a Government, with all the attendant directness of view and practical nature. And it is none the less surprising that nowhere in the sugar world is a higher value placed on the work of pure as well as applied science. This we have, during a long experience, come to regard as a characteristic feature of the Dutch, namely, a great appreciation of the value of modern scientific work, coupled with a peculiar capacity for the practical application of the results obtained.

For the administration of the affairs of the industry as a whole, at any rate those factories which have agreed to pay the cesses, two main bodies have been called into existence, a General Syndicate of Sugar Manufacturers and a Research Station Association. The GENERAL SYNDICATE, with headquarters at Soerabaia, is maintained by a cess of 1.25 guilders per bouw (the guilder = 1s. 8d., and the bouw = 1¾ acres), up to a limit of 1750 bouws under one control. Its sphere of action is of an economic and political nature, and its forms a channel through which its members can make their influence felt by the Government, as to the relations between factories and land-owners, the levying of export duties, and matters of similar nature. The functions of the Syndicate are divided between three separate bodies, the General Assembly of Members, a Council, and a Board. The Assembly usually meets twice a year (although special meetings may be called), and its main work is the fixing of the annual contribution by the members, passing the accounts, and sanctioning the budget. The Council is a purely advisory body, but from the nature of its constitution (mentioned below) it has great influence with the Board, which is the main executive body. The Board usually meets once a month, under a president who has large powers for the transaction of ordinary business between the meetings, and is assisted by a permanent paid staff. Half of the members of the Board are nominated by the Council and the other half selected by the Assembly, which also appoints the president. For keeping in touch with all the factories which are members of the Syndicate. the island is divided into 16 sections, which more or less correspond with the Government administrative divisions, and each of these sections has a local Board, whose chairman is always the manager of a factory within its limits. It is the 16 chairmen of these local Boards who form the Council of the Syndicate, as well as the Council of the Research Association

to be referred to later. Thus, all parts of the industry are fully represented in the management of affairs.

The RESEARCH ASSOCIATION, which appears to have a similar constitution to the General Syndicate, deals with agricultural and manufacturing matters, and has, as is natural, a more complicated network of sub-divisions. Under the executive Board there are three independent departments: Agricultural, with headquarters at Pasoeroean, and Chemical and Engineering at Semarang. It will be necessary briefly to consider the work of each of these. The funds of the Association are derived from a cess of 4½ guilders per buow under cane, with an additional half guilder where a "group adviser" is employed (as detailed below), making a total of 5 guilders per buow, up to the limit of 1750 buows under one factory as before.

THE AGRICULTURAL DEPARTMENT. To the buildings at Pasoerocan a farm of 25 bouws is attached, for the use of workers in the various sections, with the novel condition that the land is rented season by season, just as is the case with factory lands. There is also a sub-station at Cheribon, in West Java. There are a director, assistant director, and secretary, and scientific heads of the following sections: Physiology, agro-geology (including the chemical analysis of soils) ,cane-breeding, bacteriology, statistics, and field experiments. Formerly there were also entomological and mycological officers, but these have been abolished as no langer needed, because of the successful control of pests and diseases by efficient cultivation. Broadly speaking, the work of the departments is concentrated on seeing that the right kind of cane is grown on the right soil, the evolution of hardy and heavy yielding varieties of cane, and the elimination of disease by proper control. The most important investigation at present being carried out is on varieties, but much is also being done on the testing of seed from different sources (e. g., hill and plains nurseries), reduction of sets per acre, depth of planting, width of rows, possibility of replacing sulphate of ammonia by some other manure, the amount of nitrogen needed per bouw for every field, the necessity or otherwise of phosphatic manures, the best time of applying manures, the use of waste products, etc. In order to keep the work at Pasoeroean available for the plantations, a special set of touring officers is attached to the section of field experiments. There are at present about 11 of these, and each has from 10 to 20 factories in his circle. They communicate the Pasoeroean results to the managers, and are consulted by them as to varieties, diseases, etc., and are therefore termed "group advisers." They collect information for the heads of sections, make soil surveys and a soil map of all plantations employing them, and conduct on the average one experiment each year on every estate which is willing to bear the cost. This is usually readily conceded, as the experiments are almost invariably financially profitable.

The CHEMICAL and ENGINEERING DEPARTMENTS are stationed at Semarang, and are under a joint head who is a vice-president of the Research Association. Each has its own director and secretary. The Chemical Department has two sections, one of which deals with purely scientific matter, analyses, etc., while the other deals with technical research and chemical control in factories. The Engineering Department has also two sections, the first having four sub-sections, namely, consulting, technical research, mill control, and office, while

the second is purely electrical. The heads of these sections and sub-sections are recruited from the Technical School at Delft. Among the subjects at present being worked out are briquetting of bagasse, behavior of bagasse under pressure, the best methods of taking samples for mill work, the best methods of driving mills by electricity, and so on. The two departments publish fortnightly figures of the working of the factories on the chemical and engineering sides, and prepare a complete synopsis of the season's results. As the officers constantly visit the factories, there are no group advisers.

RELATION BETWEEN THE FACTORIES AND THE LAND-OWNERS. The arrangements are a survival of the culture system of Governor Van Der Bosch a century ago, all compulsion having long ceased; and the success of the industry is largely dependent on the agricultural control of the land by the factories during the term of their lease. No non-native can acquire land in Java from a native, and the longest lease is therefore fixed at 21½ years, although it is usually much shorter, namely, for the time required to grow one crop of canes, roughly a year and a half. Rent is fixed at a figure supposed to equal the profit which could be obtained from one crop of rice and two dry crops, which could be raised in the time, and is subject to revision every five years. The minimum rent as fixed by Government is now about 60 guilders per bouw per annum, or 90 guilders for the season; besides this, from 2 to 7½ guilders are paid for returning the land to its normal condition for a rice crop. Competition between factories for the land is impossible, for they have to be licensed by Government and are not allowed to interfere with one another or with the food growing needs of the people. For safeguarding the latter not more than one-third of the land in any village may be leased. New licenses are now very rare and the number of factories in Java has for some time been practically stationary.

CULTIVATION. The most interesting of the methods employed by Java is that of procuring sets for planting. These are obtained from three sources: hill nurseries (1000-3000 ft.), plains nurseries and tops of the crop cut on the plantations; and owing to the great cost of the first, the tendency is to increase the second source, the nurseries either being off the estate but at a lower level, or even on the estate itself. In both kinds of nurseries no cane is harvested, but the plants are cut up after six months' growth, producing two to three sets each stalk. In the plains nurseries another method is also employed, only the top being cut off and the remainder being left to grow for a further 10-45 days, after which the whole is cut up: each set then has one or two young shoots whose leaves are trimmed to prevent evaporation. These shooting sets are termed *"rajoengans"* and are used for middle and later sowings. They are only produced on factory lands, as they cannot be transported far. Some sets are always obtained each year from the hill nurseries, the average for most of Java in 1918 being 35 per cent hills; 31 per cent plains; 34 per cent tops; while in Djokjakarta, where the climate is favorable, the figures were 4 per cent, 66 per cent, and 30 per cent, respectively. The quantity of hill sets required for one bouw in 1919 was 3½-4½ tons, costing 93 guilders per bouw (66s. per acre), against 40 guilders per acre (30s. 8d. per acre) for plain sets. The method of nurseries permits of very rapid multiplication of new varieties, as this is at the rate of eight times in six months, or

4096 times in two years. With the preliminary period of testing at Pasoeroean, which is severe and lasts two or three years, it takes a minimum of five years for a new variety to be extended over 5000-6000 bouws.

An interesting table is given of the changes which have taken place in the varieties grown in 1912, 1919 and 1920. The most marked feature is the diminution of 100 P. O. J. and 247 B (the correct naming of J 247). The increases have been in E. K. 28, D. L. 52 and, to a less extent, in E. K. 2, none of which is found in the 1912 list.

The laying out of the cane field in Java after rice is comparatively well known and is left out here for want of space. It may be mentioned that the rate of converting the sodden paddy land into friable sugar cane soil appears to be little less than miraculous, and seems to be due to the fact that the soil in Java sugar estates does not suffer by being worked wet, but as soon as it dries it becomes friable and well aired. The preparation commences as the paddy harvest is being reaped, and as much as 50 per cent of the trenches and furrows on a 3000-acre estate is completed by the time that the paddy is completely cut. After the furrows and trenches have been finished, the land is left to air for five or six weeks before planting commences. Cultivation is almost entirely done by hand labor, and this alone will preclude any other country from following the system, even if its soil will bear such drastic treatment. Water for irrigation is almost always sparse and the greatset care is necessary to avoid waste: the sets are never flooded, but merely splashed at frequent intervals when recently planted, a proceeding again demonstrating a good labor supply.

Ammonium sulphate is the manure most used, there being usually two doses at three and seven weeks from planting; the manure is placed in small holes on opposite sides of the young plants and covered over. The economic optimum worked out at Pasoeroean is 400 lbs. per acre (80 lbs. N.), but many factories have worked out their own optima, and in some cases have found it to be as much as 550 lbs., in which case the manure is applied in three doses, at three, seven, and elevent weeks from planting. Occasionally phosphates are given, but potash is not needed, and these elements appear to be added to the soil in sufficient quantity by the water irrigating the paddy crop. A case is noted of a dry, coarse, sandy land, where 1500-2250 lbs. of molasses per acre gave useful results by improving the water-holding capacity of the soil.

Details are given in a table of the cost of production of cane, and this is compared with that on two of the chief experimental stations in India. The cost of cane at the factory in Java, on 177 plantations, in 1918 worked out at 4.63 annas (or pence) per standard Indian maund (about 82 lbs.), or one anna less than the Indian examples, which, however, were obviously not strictly comparable.[1]

SUPERVISION. This is wholly in the hands of Europeans, whether in fields or factory, and much of the efficiency in the industry is undoubtedly due to this fact. An important part of the European staff is recruited in Holland,

[1] In Chapter II of the Report, the rupee is taken for convenience as the exact equivalent of the guilder, that is at 1s. 8d. On this basis, 4.63 annas equal 5.9 pence. With the rupee at 1s. 4d., as it is at present, the anna exactly equals the penny.

and many of them are graduates of the Agricultural High School at Wageningen or of the Technical High School at Delft. Wherever possible young chemists are employed in the factories for three or four years and then offered posts as assistant managers, and the chance of being promoted to factory managers depends on their ability to master the agricultural side. The Research Station officers, not being Government officials, are interchangeable with those of the factories. An important feature is the great importance attached to the possessions by all higher officials in a factory, whether chemists or engineers, of a knowledge of all branches of factory and plantation work. The average number of Europeans on an estate (factory and plantation) of 1200 bouws (2100 acres) is 20.

Factory Work. The sugar factories in Java are up-to-date, roomy and efficient. They are 186 in number, and of these returns are available from 138 to 145, though engineering details are only available from 77 to 100. Crushing lasts from May to October, with slight variations from these dates in certain districts: the average length of season is 126 days, or just over four months. The canes are brought from the fields in 6-8 ton trucks, which are run alongside the carrier: the contents are hoisted bodily by electric cranes to a sloping platform, from which they are conveyed to a carrier by means of a mechanical rake. Of 77 factories, there are eight with 14-roller mills, eleven 12-roller, twenty-four 11-roller, thirty-three 9-roller, and only one 8-roller.

The sugar house processes are ordinary defecation (lime), sulphitation (lime and sulphurous acid), and carbonatation (lime and carbonic acid); and, in 1919, the proportion of these in the factories were 49 per cent, 38 per cent, and 13 per cent, respectively. Careful boiling and vacuum pan work, together with slow cooling in the crystallizers has, in Java, secured a high yield of sugar and a reduction in the quantity of molasses. The largest factory in Java produced, in 1918, 44,386 tons of sugar, and its progress from 1915 to 1918 is shown in a table from which the following is taken: The cane crushed rose from 362,077 tons to 407,955; the sugar produced from 24,332 tons to 44,386; the parts sucrose in 100 cane from 9.0 to 12.76; the parts sugar obtained per 100 cane from 6.72 to 10.88; and the sugar lost or left in the molasses in 100 cane was reduced from 2.28 parts to 1.88.

"It will be observed," the Committee remarks, "that the cane worked up in 1918 was so much better than that of 1915 and the efficiency of the factory had so much improved that, although only 12.7 per cent more cane was crushed 82.4 per cent more sugar was produced." An interesting indication of the progress made in the workings of the Java factories as a whole is shown in another table, where averages are given of returns from 138 to 143 factories during the same years, the improvement being steadily progressive under each heading from year to year. The fiber was reduced from 13.26 to 12.99 per 100 parts of cane and the parts sucrose increased from 11.63 to 13.63; the purity of the mixed juice rose from 82.0 to 86.5, while the parts glucose per 100 mixed juice fell from 1.32 to 1.0; the purity of the clarified juice rose from 83.5 to 87.9; the parts sugar obtained per 100 parts cane rose from 9.36 to 11.32 and the parts molasses fell from 3.28 to 2.78 (2.73 in 1917); the number of factories working

with cane with 13 parts or more of sucrose per 100 cane rose from 8 to 102 (or 5.80 per cent to 71.33 per cent), and the number of factories working on cane with 10 parts or less sucrose per 100 cane fell from 10 to 0.

LABOR. The matter of labor is simplified by the denseness of the populations. Java, with 50,000 square miles of area, has some 34 millions of people. The labor is entirely voluntary and the present rates are 8 annas for men, 5½ for women, and 4 annas for children. Hence the land-owners secure a reasonable rent for their land together with sufficient continuous employment to yield an income equal to that which they would have got if they cultivated the land themselves; and those who cultivate their own lands have a market for their labor during the milling season. In the factory the skilled labor is usually in the hands of the Chinese, who receive 10 as. to Rs 2 per day, while the unskilled labor is supplied by Javanese at 7½ to 9 annas.

The Committee concludes this chapter on Java as follows: "Whilst there can be no doubt that, as the result of the traditions of the forced culture system, the Java sugar industry has had exceptional advantages in securing land and labor for cane production, it is equally unquestionable that these alone would not have been sufficient to ensure it the commanding position it at present holds. This has been secured by an admirable organization for mutual assistance in all directions, above all in regard to research, generous expenditure in which it is recognized to be a most profitable investment, and by the adoption of methods of cultivation and manufacture on which it would be difficult to improve, carried out under highly trained and well paid supervision. The sugar industry in Java was certainly not in a more favorable position for commanding land and labor in 1918 than in 1894, but whereas the outturn of sugar in 1894 was 2.81 tons per acre, in 1918 it was 4.34 tons. In 1919 it fell to 3.86 tons, but, owing to prolonged drought, the circumstances of the latter year were exceptional. The result is, as Mr. Keatinge, Director of Agriculture in Bombay, stated in 1914, that Java sugar dominates the Eastern markets, and that not only is the industry able to dispense with any protection, subsidy or assistance from Government, but it successfully forces its way through hostile tariffs and pays high dividends on invested capital.

"We have endeavored to give as accurate a picture as possible of the present conditions of the Java sugar industry. It must, however, be remarked in conclusion that many of the conditions are undergoing rapid and material change. Costs of both cultivation and manufacture are rising, labor difficulties are increasingly felt, and political developments threaten to affect the hitherto amicable relations between the factories and the land-owners. The industry is thus not entirely secure in the position it has so successfully established, and its difficulties and problems appear likely to multiply rather than to diminish in the years that lie before it." [J. A. V.]

Annual Synopsis of Mill Data 1921.

By W. R. McAllep.

Data from 40 factories appear in this Synopsis. But one factory in the Association did not report. This omission does not affect the averages, as the sugar produced at this factory was less than 0.2% of the total crop. This Synopsis does fall short of representing the 1921 crop, however, because the harvest has been prolonged. Six factories only had finished grinding on October 1, the latest date on which reports for this Synopsis could be made. Fifteen per cent of the crop was still unground on this date.

The general arrangement of the large tables is the same as in the last three or four years, the factories being listed in the order of the size of the crop, taking as a basis the average of the preceding five seasons. The first of the large tables contains the analytical data, losses, recoveries, etc. True averages, together with the averages for the preceding nine seasons, also appear. The second and third of the large tables are compiled so that engineers may have details of the settings, grooving, speed, etc., of all of the factories. The second table is a compilation of knife, roller and returner bar data, speed of the rollers and pressure. Surface and juice grooving in use this season appear in the third table.

Varieties of Cane.

The proportion of the principal varieties of cane ground at the different factories and true averages for the preceding three seasons appear in Table 1.

The tonnage of Lahaina has decreased till it now holds second place by a narrow margin. One-half of the factories ground H 109 in quantities amounting to 1% or more of their crop. The tonnage of this variety has increased till it is now in third place, having passed D 1135, though the latter variety shows a material increase over previous years. The proportion of Yellow Caledonia is larger than last season. The variation is apparently on account of the bi-yearly harvest. The tonnage of Tip canes has decreased.

Of the minor varieties included in the column "Other Varieties," those that formed 1% or more of the crop of any plantation are:

Variety—	% of Total Crop.
Rose Bamboo	1.02
H 146	0.93
H 20	0.23
H 227	0.17
Yellow Bamboo	0.14
White Bamboo	0.10
H 223	0.05
Badila	0.04
	2.68

TABLE NO. 1.

VARIETIES OF CANE.

	Yellow Caledonia.	Lahaina.	H 109.	D 1135.	Striped Tip & Yellow Tip.	Striped Mexican.	D 117.	Other Varieties.
H. C. & S. Co.	..	42	49	8	..	..	..	1
Oahu	..	39	33	20	..	..	..	8
Ewa	1	38	59	..	..	..	..	2
Maui Agr.	..	49	36	6	..	..	..	9
Pioneer	..	40	6	11	..	41	..	2
Waialua	22	28	9	14	..	..	..	27
Haw. Sug.	5	21	19	43	..	..	..	12
Olaa	90	..	..	8	..	..	..	2
Honolulu	59	19	17	5	..	..	..	..
Onomea	96	..	..	1	3	..	..	..
Kekaha	..	72	4	18	..	..	..	6
Hakalau	100	..	..	..	..	..	..	..
McBryde	31	2	34	33	..	..	..	..
Hilo	95	..	..	5	..	..	..	..
Lihue	95	..	3	1	..	..	..	1
Haw. Agr.	56	..	..	17	..	8	..	19*
Wailuku	1	29	30	5	..	29	..	6
Makee	100	..	..	..	..	..	..	..
Honokaa	10	..	10	66	14	..	..	..
Laupahoehoe	56	..	..	3	33	..	8	..
Waiakea	100	..	..	..	..	..	..	..
Kahuku	50	17	33	..	..	..	..	..
Pepeekeo	100	..	..	..	..	..	..	..
Koloa	89	7	4	..	..	..	..	..
Hamakua	50	..	1	14	4	..	30	1
Paauhau	53	..	2	36	4	..	3	2
Honomu	97	..	..	..	..	..	3	..
Hawi	54	..	10	4	32	..	..	..
Hutchinson	43	..	..	..	3	..	..	54†
Kaeleku	100	..	..	..	..	..	..	..
Kaiwiki	66	..	..	2	4	..	27	1
Waianae	..	59	35	1	..	2	..	3
Kilauea	100	..	..	..	..	..	..	..
Kohala	40	..	..	18	42	..	..	..
Waimanalo	100	..	..	..	..	..	..	..
Niulii	78	..	..	..	22	..	..	..
Halawa	36	..	..	5	59	..	..	..
Olowalu	..	58	37	..	..	5	..	..
Union Mill	38	..	..	7	55	..	..	..
Kipahulu	100	..	..	..	..	..	..	..
True Average 1921	45.1	17.4	15.0	11.0	3.0	3.0	1.1	4.4
" " 1920	42.7	26.7	9.1	10.0	3.5	2.5	1.0	4.5
" " 1919	46.4	29.1	6.8	7.2	2.9	1.8	1.1	4.7
" " 1918	42.9	37.9	4.0	7.5	2.0	0.6	0.8	4.3

* White and Yellow Bamboo 7%.
† Rose Bamboo.

TABLE NO. 2.

COMPOSITION OF CANE BY ISLANDS.

	Hawaii	Maui	Oahu	Kauai	Whole Group
1912					
Polarization	13.30	16.00	14.38	14.06	14.34
Percent Fiber	13.53	11.53	12.62	12.59	12.67
Purity 1st Mill Juice	88.40	91.13	88.46	88.30	89.04
1913					
Polarization	13.22	15.56	14.21	13.70	14.05
Percent Fiber	13.74	11.73	12.75	12.50	12.85
Purity 1st Mill Juice	88.47	91.11	88.20	88.12	89.02
1914					
Polarization	12.75	15.16	14.23	13.62	13.78
Percent Fiber	13.62	11.59	12.44	12.75	12.74
Purity 1st Mill Juice	88.22	91.02	88.11	87.51	88.71
1915					
Polarization	12.61	15.23	14.29	14.09	13.77
Percent Fiber	13.00	11.44	12.77	12.46	12.51
Purity 1st Mill Juice	87.86	90.48	87.27	86.99	88.24
1916					
Polarization	12.54	14.62	13.74	13.26	13.45
Percent Fiber	13.22	12.22	12.51	12.86	12.74
Purity 1st Mill Juice	87.56	89.41	87.15	86.26	87.70
1917					
Polarization	13.31	15.43	13.55	13.13	13.76
Percent Fiber	13.23	11.67	12.25	12.89	12.62
Purity 1st Mill Juice	88.11	90.69	86.86	86.70	88.02
1918					
Polarization	11.88	14.25	13.50	12.54	12.97
Percent Fiber	13.35	11.53	12.23	12.84	12.50
Purity 1st Mill Juice	87.27	88.62	86.93	85.88	87.18
1919					
Polarization	12.74	15.12	14.24	13.52	13.74
Percent Fiber	13.07	11.74	12.14	12.61	12.49
Purity 1st Mill Juice	87.54	88.81	87.00	85.82	87.34
1920					
Polarization	12.86	15.29	13.75	13.07	13.64
Percent Fiber	13.36	11.39	12.65	12.72	12.64
Purity 1st Mill Juice	87.87	88.94	85.40	86.52	87.24
1921					
Polarization	12.25	14.67	13.72	12.67	13.12
Percent Fiber	13.28	11.82	12.40	13.28	12.80
Purity 1st Mill Juice	87.18	87.37	85.46	84.07	86.22

H 245 was ground in approximately the same quantities as Badila, but did not constitute 1% of the crop at any one plantation.

Quality of Cane.

In quality the cane was much poorer than last year. The purity of the first mill juice was lower by some one per cent than in any year for which figures are available. The polarization was lower than in any year except 1918. Judging by the quality ratio, the cane was slightly better than the low point reached in 1918, but poorer than in any other year. The fiber content was higher than in other years except 1911 and 1913. Delayed harvesting has been responsible to a large extent for the poorer quality of the cane.

The composition of the cane by islands is shown in Table 2. In quality of cane, the different islands are in the same relative order as in previous years; that is Maui, Oahu, Kauai and Hawaii. Both polarization and purity show a large decrease compared with last year on all islands, except Oahu. On this island the delayed harvesting conditions were somewhat similar to those of the preceding season and the decrease in the quality of the cane is small.

Milling.

A reduction in the average milling loss of from 2.75 to 2.64 indicates a continuation of the improvement in milling. The extraction has not kept pace with the reduction in milling loss because of higher fiber in the cane, and instead of being higher is actually 0.02 lower than last year.

The polarization of the bagasse has decreased from year to year. This has continued during this season.

The same has been true of the moisture content of the bagasse in previous years. This year, however, for the first time since the figures have been averaged, the moisture content of the bagasse is higher than it was the preceding season. The increase is not great, the figures being 41.05 and 41.20. If we class the first twenty factories in the tabulations as the larger and the last twenty as the smaller, we find that this increase is due to the work of the smaller factories, the average for the larger factories being the same as last year.

The amount of maceration has again decreased, and is now 1.5 below the maximum reached in 1919. Over 60% of the factories report decreased maceration.

While methods for determining the efficiency of the maceration are far from satisfactory, there is ample evidence to indicate that it is low. If the efficiency of the maceration can be increased the amount used can be reduced without detracting from the work. It is probable that with a given sucrose extraction, an increase in the efficiency of the maceration will decrease the extraction of impurities. This is a subject worthy of the attention of the engineers.

New records have been established this season in both milling loss and extraction. Table 3 shows the factories ranked according to milling loss. Two factories, Onomea with 1.16 and H. C. & S. Co. with 1.25 have exceeded the record for milling loss of 1.27 made last year by Maui Agricultural Co. H. C. & S. Co. has also established a new record for extraction, finishing the season

TABLE NO. 3.—MILLING RESULTS.

Showing the Rank of the Factories on the Basis of Milling Loss.

	Factory	Milling Loss	Extraction Ratio	Extraction	Equipment
1.	Onomea	1.16	0.09	98.81	2RC60,S54,12RM66
2.	H. C. & S. Co.	1.25	0.08	99.07	K(2),2RC78,S72,15RM78
3.	Maui Agr.	1.35	0.10	98.90	K(2),21RM66
4.	Hakalau	1.37	0.11	98.62	2RC54,12RM9-60,3-66
5.	Hilo	1.44	0.11	98.47	K,2RC60,12RM66
6.	Pepeekeo	1.83	0.15	98.09	2RC54,9RM60
7.	Makee	2.12	0.18	97.46	K,2RC72,S72,9RM72
8.	Ewa	2.13	0.15	98.14	K(2),20RM78
9.	Wailuku	2.18	0.16	98.08	K,2RC72,12RM78
10.	Honomu	2.19	0.17	97.79	2RC60,9RM60
11.	Paauhau	2.21	0.19	97.29	2RC60,12RM66
12.	Koloa	2.28	0.19	97.29	K,2RC60,12RM66
13.	Haw. Sug.	2.38	0.17	98.05	K,2RC72,S72,12RM78
14.	Lihue	2.50	0.21	97.10	K,2RC78,S72,12RM78
15.	Honokaa	2.57	0.24	96.91	K(2),14RM2-60,12-66
16.	Haw. Agr.	2.62	0.23	96.94	3RC60,12RM66
17.	Kilauea	2.73	0.24	96.66	K,S,3RC60,9RM60
18.	Pioneer	2.81	0.19	97.84	K,2RC72,S72,15RM72
19.	Laupahoehoe	2.81	0.22	97.01	K,2RC60,9RM60
20.	McBryde	2.89	0.23	96.80	K,2RC72,S54,9RM84
21.	Waianae	2.92	0.21	97.34	K(2),12RM60
22.	Olaa	3.06	0.25	96.83	K,S72,12RM78
23.	Hawi	3.08	0.23	97.14	K(3),3RC48,12RM3-48,9-54,14RM54
24.	Olowalu	3.09	0.24	97.04	K,3RC48,9RM48
25.	Waialua	3.16	0.22	97.40	K(2),14RM78
26.	Kekaha	3.16	0.22	97.24	2RC54,9RM60
27.	Hutchinson	3.26	0.28	96.31	2RC60,9RM60
28.	Honolulu	3.28	0.24	97.00	K(2),S54,11RM78
29.	Kahuku	3.34	0 27	95.71	3RC60,S54,9RM72
30.	Oahu	3.57	0.26	96.95	K(2),2RC78(2),S72,12RM78(2)
31.	Kohala	3.67	0.30	95.92	K(2),12RM60
32.	Kaiwiki	3.79	0.30	95.55	K,2RC60,9RM60
33.	Kaeleku	3.84	0.34	95.35	K(2),11RM2-54,9-60
34.	Waiakea	4.20	0.33	95.41	K,S42,11RM60
35.	Hamakua	5.31	0.41	94.13	K,2RC60,12RM60
36.	Halawa	6.03	0.54	92.49	K,2RC60,6RM50
37.	Union Mill	6.50	0.55	91.53	K,9RM60
38.	Niulii	8 50	0.71	89.86	K(2),9RM54
39.	Kipahulu	9.02	0.73	89.85	K,5RM3-42,2-54

with an average of 99.07. Five factories have reported milling losses of less than 1.5, against a maximum of two in any previous year. Compared with 1920, Ewa, Wailuku, Honokaa, Koloa, Hawi and Makee have advanced materially in their relative standing. These factories have also made material reductions in their milling loss. Olowalu, Kekaha, Kilauea, Waianae, Oahu and Pioneer are this year materially lower in their relative standing.

Gravity Solids and Sucrose Balances.

Table No. 4 shows these balances for the factories reporting the necessary data. As in previous years where suspended solids in the mixed juice has not been given it has been estimated at 0.25%.

The use of sucrose figures eliminates several errors that exist in the ordinary control based on polarization. These methods have been improved and simplified so that satisfactory determinations may be made by laboratory assistants. At the recent meeting of the Hawaiian Chemists' Association, estimates of the time required for the extra determinations varied from half an hour to an hour and a half a day. Twenty-one factories, manufacturing 65% of the crop, have this year made the necessary determinations. It would appear to be but a short step, yet a very desirable one, for this to be done by the remaining factories, thus putting the control on the much more reliable sucrose basis.

Boiling House Recovery.

The recovery compared with the available calculated from the analysis of the syrup appears in Tables 5 and 6. These tables are principally a check on the chemical control. It is necessary in calculating Table 5 to make the assumptions explained in the note at the bottom of the table. These assumptions, while true for average conditions, are not necessarily exact for individual cases. Comparisons over a number of years indicate that inaccuracies thus introduced are probably not over one per cent and that a figure of over 101% indicates errors in the control. Figures under 99 may indicate errors in the control or actual losses. There would seem to be no reason, other than errors in the control, why the figure for available based on true sucrose in Table 6 should be over 100.

But one factory is over 101% in Table 5, and but two over 100% in Table 6. This is a better showing than in any previous year and an indication of improvement in the chemical control.

Molasses Produced on Theoretical.

This Table No. 7 has again been included. The figures this year are considerably more consistent than last season. As has been previously explained this table has been calculated on gravity solids. Using this basis, the only one available, a discrepancy is introduced which makes the molasses accounted for less than the calculated theoretical. It is probable that from 85% to 95% of the theoretical amount should be accounted for.

Examination of the figures shows that 10 factories have reported less than

TABLE NO. 4.

GRAVITY SOLIDS AND SUCROSE BALANCES.

Factory	Gravity Solids per 100 Gravity Solids in Mixed Juice				Sucrose per 100 Sucrose in Mixed Juice			
	Press Cake	Commercial Sugar	Final Molasses	Undetermined	Press Cake	Commercial Sugar	Final Molasses	Undetermined
H. C. & S. Co.	5.7	74.7	16.6	3.0	0.5	89.4	7.6	2.5
Oahu	3.9	74.8	19.0	2.3	0.2	89.2	9.4	1.2
Ewa	5.8	67.9	23.1	3.2	0.3	85.5	11.1	3.1
Maui Agr.	5.4	75.4	20.2	—1.0	0.2	90.3	9.5	0.0
Pioneer	2.7	75.1	20.2	2.0	0.2	89.3	9.1	1.4
Waialua	7.9	66.2	26.0	5.3	0.3	82.9	11.0	5.8
Onomea	5.1	77.3	15.6	2.0	0.1	91.7	6.8	1.4
Hakalau	3.7	79.7	14.5	2.1	0.2	92.8	6.4	0.6
Hilo	4.1	79.7	13.8	2.4	0.2	92.7	6.0	1.1
Haw. Agr.	3.4	73.9	20.2	2.5	0.1	86.9	9.4	3.6
Wailuku	3.0	72.4	22.8	1.8	0.2	87.0	10.8	2.0
Makee	2.1	67.6	23.7	6.6	0.3	83.7	11.9	4.1
Laupahoehoe	4.3	75.2	19.9	0.6	0.1	88.3	9.7	1.9
Waiakea	4.5	73.3	17.6	4.6	0.3	87.5	9.1	3.1
Pepeekeo	4.3	76.5	16.5	2.7	0.2	91.5	7.2	1.1
Hamakua	3.9	70.4	9.4	16.3	0.5	83.7	4.6	11.2
Paauhau	7.6	73.2	18.1	1.1	0.4	90.2	8.4	1.0
Honomu	5.2	77.9	15.4	1.5	0.3	92.4	6.6	0.7
Hutchinson	3.2	74.3	13.4	9.1	0.3	86.1	6.8	6.8
Kilauea	2.9	62.9	24.4	9.8	0.5	79.4	13.1	7.0
Kohala	7.8	72.8	16.1	3.3	0.3	90.5	8.0	1.2

80% of the theoretical amount of molasses. All of these factories have undetermined losses larger than the average. But three factories reporting over 80% of the theoretical amount of molasses have undetermined losses of over 2%.

Boiling House Work.

During the seven years for which average increases in purity from mixed juice to syrup are available these figures have shown an almost continuous decrease. The present average, 1.13, is 0.20 below the previous low point reached last year. Milling practice has changed materially in these seven years, and without doubt an increased amount of fine cush cush now passes the mill screens and enters the boiling house with the mixed juice. During clarification a part of this cush cush is dissolved, adding to the impurities in the juice and diminishing the increase in purity. Screening practice is in need of revision to meet this new condition and insure the recovery of the extra sugar extracted by improved milling.

This season delays have also diminished the increase in purity and added to the losses. Such losses are due to the development of micro-organisms in liquors cooling to the point where such development can take place and to chemical inversion in liquors that are not sufficiently alkaline. Though such losses cannot be entirely avoided during delays, they can be reduced to less than what the writer has frequently observed, by maintaining temperatures in the settling tanks, filter presses and even in the syrup tanks above the point where micro-organisms can develop and keeping the products sufficiently alkaline so that chemical inversion will not take place.

Though experimental work has not yet covered a sufficiently wide variety of cases to estimate the possible increase in purity, it is safe to state that the present average can be materially improved.

The lime used in clarification was slightly in excess of the amount used the previous season.

The polarization of the press cake has increased slightly, while the weight has decreased in somewhat greater proportion, resulting in a slightly lower loss per cent cane. Due to the lower polarization of the latter, however, the loss per cent polarization of cane shows a slight increase.

It is improbable that the small loss reported in the press cake represents all the loss at this point. It is not easy to maintain temperature conditions in the presses that will prevent bacterial growth. More often than not there is evidence of bacterial development during washing, if not indeed during filtration itself. The writer is convinced that the actual loss is usually much greater than that indicated by the analysis of the washed cake.

While the syrup was evaporated to a higher density than last season, this point was not as high as has been reached in several previous years.

The polarization of the commercial sugar has increased from 96.36 to 96.75, changed marketing conditions having made this increase profitable. Higher polarization has depressed the boiling house recovery 0.17. This is not, however, a loss as it has been taken into consideration in calculating the most profitable polarization.

TABLE NO. 5.

APPARENT BOILING-HOUSE RECOVERY.

Comparing percent available sucrose in the syrup (calculated by formula) with percent polarization actually obtained.

Factory	Available *	Obtained	Recovery on Available
H. C. & S. Co.	91.57	90.92	99.29
Oahu	89.48	90.35	100.97
Ewa	88.23	86.50	98.04
Maui Agr.	91.25	90.49 †	99.17
Pioneer	90.70	89.43	98.60
Waialua	88.35	83.62	94.65
Haw. Sug.	91.38	91.21	99.81
Olaa	90.15	90.26	100.12
Onomea	92.08	92.19	100.12
Kekaha	89.93	88.46	98.37
Hakalau	92.37	92.97	100.65
McBryde	86.93	83.94	96.56
Hilo	93.25	92.82	99.54
Lihue	86.38	85.77	99.29
Haw. Agr.	90.87	87.56	96.36
Wailuku	88.89	87.63	98.58
Makee	85.37	84.46	98.93
Honokaa	87.13	85.56	98.20
Laupahoehoe	91.15	89.38	98.06
Waiakea	89.30	87.97	98.51
Kahuku	87.58	74.68	85.27
Pepeekeo	91.62	92.15	100.58
Koloa	87.29	86.70	99 32
Hamakua	89.83	84.62	94.20
Paauhau	91.47	90.33	98.75
Honomu	92.88	93.14	100.28
Hawi	91.09	81.27	89.22
Hutchinson	90.03	87.12	96.77
Kaeleku	87.27	86.93	99.61
Kaiwiki	90.22	90.24	100.02
Waianae	88.28	87.62	99.25
Kilauea	82.36	80.36	97.57
Kohala	90.10	91.29	101 32
Niulii	89.80	88.95	99.05
Halawa	88.57	78.04	88.11
Olowalu	87.44	86.29	98.68
Union Mill	87.32	80.81	92.54
Kipahulu	90 99	88.68	97.46

* In order to calculate the available sucrose it is necessary to estimate the gravity purity of the syrup and sugar. Data from factories determining both apparent and gravity purities indicate that the average correction necessary is the addition of 0.8 to the apparent purity of the syrup and 0.3 to the apparent purity of the sugar. When the moisture in the sugar has not been reported 1% has been taken. 38 has been used when the gravity purity of the molasses has not been reported.

† Sucrose.

The moisture content of the sugar has decreased from 0.97 to 0.92%. This decrease is not in proportion to the increase in polarization. A moisture content of 0.92% in such sugar is dangerously near the point where deterioration may be expected.

The gravity purity of the final molasses has decreased from 38.75 to 38.53. This is a better purity than in any year except 1919, when the average was 37.95. Compared with last year, better low grade work has had a favorable influence on the recovery to the extent of 0.10.

Last year both mixed juice and syrup were lower in purity than in any previous year. This year the mixed juice was 1.10 and the syrup 1.30 below the low points reached a year ago. A large increase in the molasses loss and a large decrease in the recovery has resulted. The following figures for the last three seasons indicate, however, that the decrease in recovery is greater than is accounted for by lower syrup purities. The average difference between apparent and gravity purities has been assumed to be the same as the average of the factories reporting both in calculating the figures for available.

Year	Available	Recovery	Recovery on Available
1919	91.87%	90.96%	99.01%
1920	91.17	89.56	98.23
1921	89.87	88.03	97.95

Increased undetermined losses have been the principal factors in the above decrease of recovery on available.

Factory Efficiency.

As there has been some misunderstanding regarding this table, the writer will quote Dr. Norris in the Annual Synopsis for 1914: "Since the object of the factory work is to transfer as much as possible of the available sugar in the cane into the bag, the extent to which it does this represents its efficiency. . . . In arriving at an accurate standard of comparison it seems to me fair, as was done by Mr. Deerr, to assume 100% extraction at the mills. . . . A gravity purity of 35 is assumed as possible in all cases." And from the 1915 Synopsis: "The calculated results are intended as an approximate gauge of the quality of the factory work."

Since the table was first published the following changes have been made: The standard for molasses purity has been reduced from 35 to 30, because it is now known that molasses can be crystallized to at least the latter point. It was at first estimated that at least one per cent increase in purity from mixed juice to syrup should be secured. The increase is now taken as it is reported, though actually many factories ought to be penalized on this score.

It should be noted that the first column is the extraction. If the fiber in the cane increases the extraction may decrease even though the same milling loss is maintained. In the same way a decrease in syrup purity will cause a lower

TABLE NO. 6.

TRUE BOILING-HOUSE RECOVERY.

Comparing percent sucrose available and recovered.

Factory	Available	Obtained	% Recovery on Available
H. C. & S. Co.	91.70	89.85	97.98
Oahu	89.59	89.38	99.77
Ewa	88.32	85.76	97.10
Maui Agr.	91.25	90.48	99.16
Pioneer	90.34	89.48	99.05
Waialua	88.39	83.15	94.07
Onomea	92.67	91.79	99.05
Hakalau	92.35	92.99	100.69
Hilo	92.91	92.89	99.98
Haw. Agr.	91.04	86.99	95.55
Wailuku	88.98	87.17	97.97
Makee	85.20	83.95	98.53
Laupahoehoe	91.19	88.39	96.93
Waiakea	89.02	87.77	98.60
Pepeekeo	91.68	91.68	100.00
Hamakua	89.64	84.12	93.84
Paauhau	91.31	90.56	99.18
Honomu	92.75	92.68	99.92
Hutchinson	90.31	86.36	95.63
Kilauea	82.82	79.80	96.35
Kohala	90.16	90.77	100.68

TABLE NO. 7.

PERCENT MOLASSES PRODUCED ON THEORETICAL.

H. C. & S. Co.	86.2	Honokaa	84.6
Oahu	90.9	Laupahoehoe	98.8
Ewa	88.1	Waiakea	79.0
Maui Agr.	105.2	Kahuku	72.2
Pioneer	91.2	Pepeekeo	85.9
Waialua	79.4	Koloa	87.3
Haw. Sug.	86.2	Hamakua	36.9
Olaa	91.2	Paauhau	93.9
Honolulu	96.9	Honomu	93.1
Onomea	83.6	Hutchinson	59.5
Kekaha	93.8	Kaeleku	88 4
Hakalau	85.2	Kaiwiki	90.2
McBryde	99.4	Kilauea	71.1
Hilo	85.4	Kohala	84 6
Lihue	77.7	Niulii	99.6
Haw. Agr.	89.0	Olowalu	74.8
Wailuku	92 5	Union Mill	73.5
Makee	78.6		

figure in column two even though the undetermined loss and the gravity purity of the molasses remain the same, provided the purity of the latter is above 30.

It would be desirable, in addition to this table, to rank the factories on a basis that would equitably allow for variations in the fiber, possible increase in purity from mixed juice to syrup, syrup purity, etc. So far the writer has not been able to devise a method for expressing this on a percentage, or indeed any other, basis.

Through the courtesy of this Association the tabulated matter in this Synopsis was presented at the recent annual meeting of the Hawaiian Chemists' Association. At this meeting suggestions made regarding the Synopsis included indicating exactly what was reported as "first mill" and "last mill" juice, and omitting the calculations per cent cane and per ton of cane from Table No. 9 and the large table.

The calculations in this Synopsis have been made by A. Brodie and W. L. McCleery.

TABLE NO. 8.

FACTORY EFFICIENCY.

Showing the rank of the factories, comparing their recovery with the calculated recovery resulting from 100% extraction, reducing the molasses to 30 gravity purity, and eliminating all other losses. Factories reporting a recovery of over 101% of the available (Table No. 5) are omitted from this tabulation.

No.	Factory	Milling	Boiling House	Over All
1	Onomea	98.81	98.03	97.01
2	Hakalau	98.62	98.15	96.96
3	Pepeekeo	98.09	98.36	96.56
4	Honomu	97.79	98.22	96.40
5	Hilo	98.47	97.47	96.11
6	H. C. & S. Co.	99.07	96.26	95.54
7	Maui Agr.	98.90	96.10	95.20
8	Pioneer	97.84	95.72	93.95
9	Oahu	96.95	96.59	93.90
10	Olaa	96.83	96.20	93.59
11	Paauhau	97.29	95.89	93.50
12	Haw. Sug.	98.05	97.06	93.26
13	Wailuku	98.08	94.61	92.97
14	Waianae	97.34	95.01	92.72
15	Ewa	98.14	94.19	92.71
16	Koloa	97.29	94.89	92.64
17	Kaiwiki	95.55	95.97	92.03
18	Lihue	97.10	94.42	91.93
19	Laupahoehoe	97.01	94.52	91.91
20	Kekaha	97.24	94.23	91.80
21	Olowalu	97.04	93.88	91.37
22	Makee	97.45	92.94	90.91
23	Haw. Agr.	96.94	93.19	90.45
24	Kaeleku	95.35	94.18	90.14
25	McBryde	96.80	92.42	89.68
26	Honokaa	96.91	92.09	89.51
27	Waiakea	95.41	93.48	89.46
28	Hutchinson	96.31	92.13	89.03
29	Waialua	97.40	89.54	87.43
30	Kilauea	96.66	89.36	86.67
31	Niulii	89.86	94.49	85.26
32	Hamakua	94.13	90.02	84.99
33	Kipahulu	89.85	93.27	84.08
34	Hawi	97.14	86.31	84.05
35	Union Mill	91.53	86.57	79.66
36	Kahuku	95.71	82.22	79.07
37	Halawa	92.49	82.71	76.73

TABLE NO. 9.

SUMMARY OF LOSSES.

FACTORY	POUNDS POLARIZATION PER TON OF CANE						POLARIZATION PER 100 CANE						POLARIZATION PER 100 POLARIZATION OF CANE							FACTORY
	Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL	Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL	Bagasse	Press Cake	Molasses	Other Known	Undetermined	TOTAL	Syrup Purity	
H. C. & S. Co.	3.0	1.6	23.6	...	4.2	32.4	0.15	0.08	1.18	...	0.21	1.62	0.93	0.52	7.61	....	1.33	10.39	85.42	H. C. & S. Co.
Oahu	8.6	0.6	26.2	...	0.4	35.8	0.43	0.03	1.31	...	0.02	1.79	3.05	0.23	9.18	....	0.15	12.61	84.5	Oahu
Ewa	5.0	0.8	29.2	...	5.8	40.8	0.25	0.04	1.46	...	0.29	2.04	1.86	0.28	11.02	....	2.19	15.35	81.61	Ewa
Maui Agr.	3.2	0.6	26.6	...	0.0	30.4 †	0.16	0.03	1.33	...	0.00	1.52 †	1.10	0.22	9.37	....	0.01	10.70 †	85.98	Maui Agr.
Pioneer	6.4	0.6	26.8	...	4.2	38.0	0.32	0.03	1.34	...	0.21	1.90	2.16	0.20	8.93	....	1.39	12.68	84.28	Pioneer
Waialua	7.4	0.8	30.6	...	14.4	53.2	0.37	0.04	1.53	...	0.72	2.66	2.60	0.25	10.81	....	5.10	18.76	84.2	Waialua
Haw. Sug.	5.6	1.8	21.8	0.2	2.6	32.0	0.28	0.09	1.09	0.01	0.13	1.60	1.95	0.62	7.55	0.09	0.93	11.15	84.22	Haw. Sug.
Olaa	7.8	1.0	21.6	...	1.4	31.8	0.39	0.05	1.08	...	0.07	1.59	3.17	0.41	8.31	....	0.58	12.97	84.6	Olaa
Honolulu	8.0	0.4	37.2	0.8	...	...	0.40	0.02	1.86	0.04	...	...	3.00	0.12	14.03	0.35	....	....	83.13	Honolulu
Onomea	2.8	0.2	16.6	...	2.4	22.0	0.14	0.01	0.83	...	0.12	1.10	1.19	0.06	6.74	....	0.97	8.96	85.5	Onomea
Kekaha	7.8	1.6	27.8	...	3.6	40.8	0.39	0.08	1.39	...	0.18	2.04	2.76	0.54	9.86	....	1.30	14.46	84.19	Kekaha
Hakalau	3.6	0.6	16.2	...	1.4	21.8	0.18	0.03	0.81	...	0.07	1.09	1.38	0.22	6.36	....	0.55	8.51	85.9	Hakalau
McBryde	8.0	0.4	34.8	...	3.8	47.0	0.40	0.02	1.74	...	0.19	2.35	3.20	0.19	13.98	....	1.53	18.90	79.93	McBryde
Hilo	4.0	0.4	15.4	...	2.8	22.6	0.20	0.02	0.77	...	0.14	1.13	1.53	0.19	5.98	....	1.10	8.78	87.3	Hilo
Lihue	6.8	1.2	24.8	1.8	5.8	40.4	0.34	0.06	1.24	0.09	0.29	2.02	2.90	0.52	10.55	0.73	2.46	17.16	79.57	Lihue
Haw. Agr.	7.0	0.4	21.4	...	6.6	35.4	0.35	0.02	1.07	...	0.33	1.77	3.06	0.13	9.19	....	2.86	15.24	85.09	Haw. Agr.
Wailuku	5.4	0.4	30.2	...	3.8	39.8	0.27	0.02	1.51	...	0.19	1.99	1.92	0.16	10.73	....	1.38	14.19	82.9	Wailuku
Makee	5.8	0.8	27.2	...	7.8	41.6	0.29	0.04	1.36	...	0.39	2.08	2.54	0.30	11.74	....	3.36	17.94	80.14	Makee
Honokaa	6.6	1.0	24.4	...	5.6	37.6	0.33	0.05	1.22	...	0.28	1.88	3.09	0.50	11.37	....	2.55	17.51	82.85	Honokaa
Laupahoehoe	7.4	0.2	23.8	...	2.0	33.4	0.37	0.01	1.19	...	0.10	1.67	2.99	0.10	9.51	....	0.78	13.38	86.52	Laupahoehoe
Waiakea	11.8	0.6	22.4	...	7.0	41.8	0.59	0.03	1.12	...	0.35	2.09	4.59	0.25	8.75	....	2.70	16.29	85.4	Waiakea
Kahuku	10.8	1.0	30.0	...	30.2	72.0	0.54	0.05	1.50	...	1.51	3.60	4.29	0.41	12.02	....	12.11	28.83	80.06	Kahuku
Pepeekeo	4.6	0.6	17.2	...	1.6	24.0	0.23	0.03	0.86	...	0.08	1.20	1.91	0.23	7.06	....	0.63	9.83	84.60	Pepeekeo
Koloa	6.6	1.0	27.4	...	4.0	39.0	0.33	0.05	1.37	...	0.20	1.95	2.71	0.38	11.27	....	1.62	15.99	80.40	Koloa
Hamakua	15.4	1.2	11.4	...	26.4	54.4	0.77	0.06	0.57	...	1.32	2.72	5.87	0.48	4.37	....	10.04	20.76	83.9	Hamakua
Paauhau	6.2	0.8	19.0	...	2.6	28.6	0.31	0.04	0.95	...	0.13	1.43	2.71	0.37	8.26	....	1.11	12.45	84.9	Paauhau
Honomu	5.6	0.6	16.4	...	0.4	23.0	0.28	0.03	0.82	...	0.02	1.15	2.21	0.26	6.52	....	0.17	9.16	86.1	Honomu
Hawi	7.4	1.0	...	...	47.4	55.8	0.37	0.05	...	...	2.37	2.79	2.86	0.37	....	....	18.12	21.35	84.6	Hawi
Hutchinson	8.6	0.6	15.4	...	13.4	38.0	0.43	0.03	0.77	...	0.67	1.90	3.69	0.29	6.61	....	5.76	16.35	85.69	Hutchinson
Kaeleku	10.4	1.4	24.6	...	3.2	39.6	0.52	0.07	1.23	...	0.16	1.98	4.65	0.63	10.98	....	1.41	17.67	81.54	Kaeleku
Kaiwiki	11.2	1.2	21.8	...	1.6	35.8	0.56	0.06	1.09	...	0.08	1.79	4.45	0.47	8.66	....	0.62	14.20	84.84	Kaiwiki
Waianae	7.4	1.0	...	...	33.4	41.8	0.37	0.05	...	...	1.67	2.09	2.66	0.38	....	....	12.00	15.04	81.65	Waianae
Kilauea	7.6	1.2	29.2	...	13.8	51.8	0.38	0.06	1.46	...	0.69	2.59	3.34	0.50	12.81	....	6.08	22.73	78.1	Kilauea
Kohala	9.8	0.8	18.6	...	1.6	30.8 *	0.49	0.04	0.93	...	0.08	1.54 *	4.08	0.33	7.67	....	0.66	12.74 *	84.1	Kohala
Waimanalo	...	1.2	...	...	...	...	...	0.06	...	...	...	...	....	....	....	....	....	....	....	Waimanalo
Niulii	24.4	1.4	23.0	...	0.8	49.6	1.22	0.07	1.15	...	0.04	2.48	10.14	0.60	9.58	....	0.28	20.60	83.71	Niulii
Halawa	16.8	1.4	...	...	45.4	63.6	0.84	0.07	...	...	2.27	3.18	7.51	0.66	....	....	20.17	28.34	83.78	Halawa
Olowalu	7.8	0.8	25.2	...	9.6	43.4	0.39	0.04	1.26	...	0.48	2.17	2.96	0.29	9.58	....	3.69	16.52	81.0	Olowalu
Union Mill	20.2	1.2	25.4	...	16.2	63.0	1.01	0.06	1.27	...	0.81	3.15	8.47	0.52	10.67	....	6.79	26.45	82.69	Union Mill
Kipahulu	25.0	3.2	...	...	24.6	52.8	1.25	0.16	...	...	1.23	2.64	10.20	1.29	....	....	9.97	21.46	84.86	Kipahulu

* A comparison of the available sucrose in the juice with the amount recovered in the boiling-house indicates that there is probably an error in some of the results reported from this factory.

† Sucrose.

Sugar Prices for the Month

Ended December 15, 1921.

		96° Centrifugals Per Lb.	Per Ton.
	(Nov. 15, 1921)	4.11c	$ 82.20
[1]	" 19	4.09375	81.875
[2]	" 21	3.9925	79.85
[3]	" 22	4.11	82.20
[4]	Dec. 8	3.98	79.60
[5]	" 13	3.86	77.20
[6]	" 14	3.765	75.30
[7]	" 15	3.67	73.40
	Average for the month.	3.94	78.95

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[1] St. Croix 3.9375. Venezuela 4.25.
[2] Cubas 4.11. Porto Ricos 3.875.
[3] Cubas.
[4] Cubas.
[5] Spot Cuba.
[6] Old crop 3.86: new crop 3.3.67.
[7] New crop Cubas.

THE HAWAIIAN PLANTERS' RECORD

Volume XXVI. APRIL, 1922 Number 2

A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

"The Record"— A Quarterly

With this number the Hawaiian Planters' Record appears as a quarterly instead of a monthly publication as heretofore. These quarterly issues will come out in January, April, July, and October. The size of each issue will depend upon available material, but will average about 75 pages, varying, perhaps, between 60 and 100 pages in the different numbers. The four issues for the year will comprise a single volume.

Less material will be reprinted from other journals than heretofore, but many articles appearing elsewhere that have an important bearing on the sugar industry of Hawaii will be reviewed or abstracted for the information of our readers. Where important articles of this character are published in foreign periodicals not readily accessible, such material will be reproduced in whole or in part, depending upon circumstances.

The editors of the Record are interested in receiving suitable contributions from individuals connected with the sugar industry of these Islands. Brief articles bearing upon better methods of sugar cane agriculture and manufacture are particularly desired.

Topping Cane for the Mill

In considering the matter of skilled supervision and its bearing on harvesting operations, we found that we did not have adequate data as to the proper point at which laborers should be instructed to top cane when cutting it for the mill. The matter was taken up with Mr. McAllep, and he and Mr. McCleery have conducted an investigation which is reported elsewhere in this number of the Record.

It is interesting to learn that through a consistent error in topping cane at the wrong place we might throw away an amount of sugar great enough to make a serious inroad upon the profits of a plantation.

The report is of a preliminary nature, but it shows that there are commercial possibilities in paying greater attention to this particular operation.

In proceeding with a study of this question we must assume that no stalk of cane can be, or will be, topped at exactly the right point, so that with each stroke of the knife an error occurs which must, at best, amount to a fraction of one per cent of the crop, and often reaches several per cent. The closer the knife can hit to the point which gives us all the recoverable sugar, and prevents the addition of green cane supplying only injurious molasses, the larger will be the yields, and in turn, profits of a plantation.

The extent to which the laborer can reduce the topping error depends upon the information and interest which we can give him in this work. Before attempting to devise ways to improve field practice at this point, the extent of the loss due to imperfect topping must first be ascertained. Upon the sugar value involved will depend the feasibility of corrective measures.

Previous investigations revealed a serious loss in deterioration between cutting or burning and milling, which in many instances has been reduced by more prompt transportation. The topping error deserves the same careful consideration, beginning first with measurements of its extent and bearing on plantation profits.

Studies in Clarification.

Work on clarification problems by W. R. McAllep and H. F. Bomonti, reported in this issue, deals with purity increases from different amounts of lime. The results indicate that there is considerable room for improvement in carrying the reaction of the clarified juice at a more alkaline point than neutrality to litmus, as is the prevailing practice in many factories.

There is a close relation between the phosphoric acid content of the juice and its behavior in clarification. A low phosphoric acid content is accompanied by difficulties in clarification. The results show the possibilities of adding phosphoric acid where this material in present in insufficient quantity.

The cost of such treatment is to be considered in connection with the fact that phosphoric acid so used is recovered in the filter-press mud.

These investigations carry valuable suggestions and the work should be supplemented by further work by factory operators pertaining to their specific conditions.

H. F. Hadfield, in an article which we also publish in this issue, relates satisfactory experience in handling the clarification at a comparatively high alkalinity.

A New Acreage Census of Cane Varieties.

Recent compilations of data, the 1921 acreage census of cane varieties, show a decided reduction in the area of Yellow Caledonia, amounting in round numbers to about 11,000 acres, as against the 1919 census. This shows the effect of a single planting season over the total cane area of the Islands and compares the entire area of the 1922 and 1923 crops with the acreage of the 1920 and 1921 crops.

H 109 shows an increase of nearly 20,000 acres, while Lahaina decreases in area by 16,000 acres. D 1135 continues to show an increase, amounting for this

period to 6600 acres. Striped Tip goes back by 1200 acres, and Yellow Tip gains by 300. Decreases are found for Rose Bamboo and D 117, and increases for Yellow Bamboo, H 146, and in a small degree for Striped Mexican.

The following table shows the situation with respect to cane varieties in condensed form:

VARIETIES OCCUPYING 1000 ACRES OR MORE.

	Census of 1919. Combined Areas of the 1920 and 1921 Crops.	Census of 1921. Combined Areas of the 1922 and 1923 Crops.	Gain in Area.	Loss in Area.
1. Yellow Caledonia	110,695	99,606	.....	11,089
2. H 109	19,826	39,770	19,944	.....
3. D 1135	21,887	28,500	6,613	.....
4. Lahaina	38,329	22,240	.....	16,089
5. Striped Mexican	5,625	5,685	60	.....
6. Yellow Tip	5,191	5,525	334	.....
7. Striped Tip	6,261	5,012	.....	1,249
8. Rose Bamboo	4,578	4,318	.....	260
9. D 117	4,607	3,735	.....	872
10. Yellow Bamboo	950	1,621	671	.....
11. H 146	1,317	1,606	289	.....

Remarkable increase in the area of H 109 and the accompanying decrease of the old Lahaina variety, which has given way to the seedling cane, are shown for a period of eleven crops as follows:

	Acres of Lahaina	Acres of H 109
Crop of 1913...............	41,208	0
" " 1914...............	39,697	26
" " 1915...............	37,394	39
" " 1916...............	35,065	558
" " 1917...............	33,110	1,160
" " 1918...............	33,910	2,847
" " 1919...............	28,624	5,414
" " 1920...............	25,078	7,147
" " 1921...............	16,706	13,471
" " 1922...............	14,052	17,501
" " 1923...............	8,188	22,269

The figures shown here are subject to minor corrections, as variety areas of a few plantations have been estimated in the absence of statistics from them.

Insect Transmission of Yellow Stripe Disease.

By L. O. Kunkel.

During the past eighteen months a number of experiments have been made in the hope of learning the means by which Yellow Stripe or Mosaic disease is spread to healthy sugar cane plants. Although the problem is by no means fully solved, some of the results seem worth recording at this time.

That many of the mosaic diseases of plants are carried by insects is now a well established fact. The Curly-top of sugar beets, a disease similar to mosaic, is carried by the sugar beet leafhopper *(Eutettix tenella* Baker)[13]; tobacco Mosaic by the spinach aphid *(Myzus persicae* Sulz.)[3]; Spinach-blight, a disease similar to mosaic, by the spinach aphid, the potato aphid *(Macrosiphum solanifolii* Ashmead), the bean aphid *(Aphis rumicis* L.), and the tarnished plant bug *(Lygus pratensis* L.)[10]; potato Mosaic by the potato aphid and the spinach aphid[11]; corn Mosaic by the corn aphid *(Aphis maidis* Fitch)[6]; cucumber Mosaic by the melon aphid *(Aphis gossypii* Glover), the striped cucumber beetle *(Diabrotica vittata* Fabr.), and the 12-spotted cucumber beetle *(Diabrotica duodecimpunctata* Oliv.)[8]; lettuce Mosaic by the spinach aphid[9]; and the Mosaic of mustard and turnip by the spinach aphid.[12] There is evidence that aphids transmit sweet pea Mosaic,[14] tomato Mosaic,[2] and the Mosaic of pokeweed *(Phytolacca decandra* L.).[1]

The fact that insects can carry so many different mosaic diseases suggests that they may be the means by which sugar cane Mosaic is spread. Shortly after beginning the work here reported, Brandes[5] published experiments showing that mosaic is carried to cane by the corn aphid. The importance of aphids in the spread of these diseases naturally brings the cane aphid *(Aphis sacchari* Zehntn.) under suspicion. For this reason it was the first insect used in my experiments.

All plants used in the experiments described below have been grown in soy tubs filled with rich garden soil. Insect control in the earlier experiments was by means of large cloth bags fitted over the tops of the tubs and held in place over the plants by short pieces of bamboo. In all the experiments set up since March 1, 1921, insect control has been accomplished by growing the plants in large insect-proof cages.

Experiments With the Cane Aphid *(Aphis sacchari* Zehntn.)

Experiment 1.—On May 1, 1920, a considerable number of cane aphids taken from a mosaic plant of Striped Tip cane on which they had been feeding for more than a month were transferred to a healthy young plant of the same variety. Another plant of the same age and variety was kept free from insects and used as a control. On July 8, when the experiment was ended, both plants were still healthy.

Experiment 2.—On May 11, 1920, a considerable number of cane aphids, taken from a mosaic Striped Tip plant were transferred to three healthy young plants of the same variety. Three other plants of the same age and variety served as controls. The aphids flourished and were present on the three test plants when the experiment was ended on July 8. They did not transmit the disease.

Experiment 3.—On May 11, 1920, a considerable number of cane aphids, taken from a mosaic plant of the Lahaina variety, were transferred to four healthy

young plants of the same variety. Four other plants of the same age and variety were kept free from insects and served as controls. All plants were still healthy on July 8 when the experiment was ended.

Experiment 4.—On May 26, 1920, a considerable number of cane aphids, taken from a mosaic plant of the Lahaina variety were transferred to two healthy young plants of the same variety. Two other plants of the same age and variety were kept free from insects and served as controls. The aphids flourished on the infested plants but had not transmitted the disease up to July 8 when the experiment was ended.

Experiment 5.—On March 1, 1921, seed from healthy Lahaina cane was planted in each of three tubs of sterile soil placed in three different insect-proof cages. In a like manner seed from mosaic Lahaina plants was placed in three other tubs of sterile soil in the three cages already mentioned. This seed, as was to be expected, gave rise to one healthy and one mosaic plant in each of the three cages. On April 20, when the plants were well started, fifty cane aphids, taken from a healthy Lahaina plant, were placed on each of the mosaic plants in the three cages. The aphids flourished on the mosaic plants and gradually spread from them onto the three healthy plants. All of the three plants from healthy seed were still healthy on July 15, when the plants in two of the cages were thrown out in order to make room for another experiment. The aphids did not transmit the disease to these plants during the period of almost three months that they were present in the cages.

The plants in one of the cages were left undisturbed until October 26. The plant from healthy seed was still free from mosaic on this date. It had produced several lalas and had grown to be a large plant. The aphids did not carry mosaic from the diseased to the healthy plant during the six months that they were present in the cage.

Experiment 6.—It is the habit of the cane aphid to feed on the lower leaves and on the more mature parts of upper leaves. Unless it becomes quite numerous on a plant it is never found on the tender young leaves of the spindle. It was thought that the failure of this insect to transmit mosaic might be due to its habit of feeding on mature tissues. On May 6, 1921, a considerable number of cane aphids, taken from a mosaic plant of the variety Demerara 117, were placed on each of three healthy young plants growing in three different insect-proof cages. Two of the plants were of the Lahaina variety, while the other was of the variety Yellow Caledonia. Approximately one hundred aphids were placed on each of these plants. Three other plants of the same age and varieties were kept free from insects and served as controls. Before placing aphids on these plants all of the mature leaves as well as the mature tips of young leaves were cut off. This was done in order to force the aphids onto the tender young tissues. All plants were still healthy on June 8 when the experiment was ended. The aphids did not transmit the disease even when forced to feed on the immature parts of young plants.

Experiment 7.—On September 19, 1921, a considerable number of cane aphids were transferred from a mosaic plant of the Lahaina variety to ten healthy young caged plants of the variety Striped Tip. Ten other caged plants of the same age and variety were kept free from aphids and served as controls. All

plants were still healthy on October 26, when the experiment was ended. The aphids failed to transfer mosaic disease to the healthy plants.

Two of our most susceptible varieties of cane, Lahaina and Striped Tip, have been used in the experiments with cane aphids. In no case did these insects transmit Mosaic disease to healthy cane plants. Although negative results are never fully convincing, the writer believes that the evidence at hand justifies the conclusion that the cane aphid takes no part in the spread of the Yellow Stripe disease.

Experiments With the Corn Aphid *(Aphis maidis* Fitch).

Experiment 8.—On March 1, 1921, two tubs of sterile soil were placed in each of twenty different insect-proof cages. Ten other tubs of sterile soil were placed outside of, but near, the cages. A seed piece cut from healthy Lahaina cane was planted in one of the tubs while a seed piece cut from diseased Lahaina cane was planted in the other tub in each cage. The ten tubs placed outside the cages were planted with healthy Lahaina seed. On March 21, it was observed that all healthy seed had given rise to healthy plants, while all diseased seed had given rise to diseased plants. On March 28, fifty corn aphids, taken from mosaic corn plants, were placed on each plant in cages numbers 2, 3, 4, 5 and 6. On April 8, fifty corn aphids, taken from mosaic corn plants, were placed on each plant in cages numbers 7, 8, 9, 10 and 11. All caged plants as well as all of the check plants growing outside the cages were examined daily. On April 20, twelve days after aphids were transferred to the last set of cages, it was observed that one stalk of the healthy plant growing in cage number 9 showed three typical Yellow Stripe spots on a young unfolding leaf. The other three stalks of this plant showed no evidence of disease. Seven days later another one of the stalks began to show Yellow Stripe spots on its unfolding leaves. On May 4, the other two stalks began to show the disease. On April 27, nineteen days after the aphids were transferred to the second set of cages, one of the two stalks of the healthy plant in cage number 10 and one of the two stalks of the healthy plant in cage number 11 began to show Yellow Stripe disease. On May 4, Yellow Stripe spots began to appear on the unfolding leaves of one of the three stalks of the healthy plant in cage number 6. The disease appeared on this plant twenty-six days after the aphids were put into the cage.

On May 10, approximately one hundred corn aphids, taken from mosaic corn plants, were placed on each of the plants in cages numbers 2, 3, 4, 5, 7 and 8. No further infection had taken place up to May 22. From this date to June 8 the plants were not under observation as the writer was absent from Honolulu. On June 8, one of the two stalks of the healthy plant in cage number 5 showed Yellow Stripe disease. The plants from healthy seed in cages numbers 2, 3, 4 and 7 were still healthy on July 16 when the experiment was ended. On this date the plants were approximately six feet high and were making vigorous growth. All of the check plants grown from healthy seed in cages numbers 1, 12, 13, 14, 15, 16, 17, 18, 19 and 20 and all of the ten check plants grown outside of cages were still healthy when the experiment was ended.

Six out of the ten healthy caged plants on which corn aphids were placed took Yellow Stripe disease, while the twenty healthy plants on which no aphids were

placed remained healthy. The experiment confirms the results obtained by Brandes and shows that this insect can carry the disease to cane.

EXPERIMENTS WITH THE CORN LEAFHOPPER *(Peregrinus maidis).*

Experiment 9.—On March 21, 1921, twenty-five corn leafhoppers, taken from mosaic corn plants, were transferred to each of two cages. Each cage contained one healthy and one diseased Lahaina cane plant. The plants were about a foot in height when the insects were transferred to them. On March 24, twenty-five more leafhoppers were transferred from mosaic corn plants to each of the cages. The insects deposited many eggs in both the healthy and diseased cane plants. A few young hoppers were hatched in each cage, but both colonies gradually died out. On April 21, twelve corn leafhoppers, taken from mosaic corn plants, were transferred to each of the cages. On June 8, when the experiment was ended, no leafhoppers could be found in either of the cages. Both of the plants from healthy seed were still healthy on this date. This experiment indicates that the corn leafhopper is not able to carry the disease to cane.

Experiment 10.—On September 27, 1921, a considerable number of corn leafhoppers, taken from mosaic corn plants, were transferred to two cages containing two healthy young corn plants and one healthy young cane plant each. The cane plants were of the Striped Tip variety. Two other cages containing corn and cane plants of the same age and varieties were kept free from insects and served as controls. On October 14, it was observed that all of the corn plants exposed to corn leafhoppers had contracted Mosaic disease; the cane plants were still healthy. On this date the diseased corn plants were cut off at the surface of the ground and left in the cages to wither. When the corn plants were dry the hoppers went onto the cane plants in large numbers. All of the cane plants used in this experiment and all of the corn plants not exposed to leafhoppers remained healthy up to October 26, when the experiment was ended. The experiments prove that corn leafhoppers can carry mosaic to healthy corn plants, but indicate that they cannot transfer the disease to healthy cane plants.

Experiment 11.—On October 26, 1921, approximately twenty-five corn leafhoppers, taken from mosaic corn plants, were transferred to a cage containing six healthy young corn plants. Six other corn plants of the same age were kept free from insects and served as controls. On December 8, 1921, when this experiment was ended, all of the six corn plants exposed to leafhoppers were infected with mosaic. The six control plants were all healthy. This experiment confirms Experiment 10 and proves that corn leafhoppers can transmit mosaic from diseased to healthy corn plants.

EXPERIMENTS WITH THE CANE LEAFHOPPER *(Perkinsiella saccharicida* Kirk).

A few tests have been made in order to determine whether or not the cane leafhopper can transfer mosaic to healthy cane plants. The results thus far obtained are negative. As work with this insect is still in progress, the experiments will not be given in detail at this time.

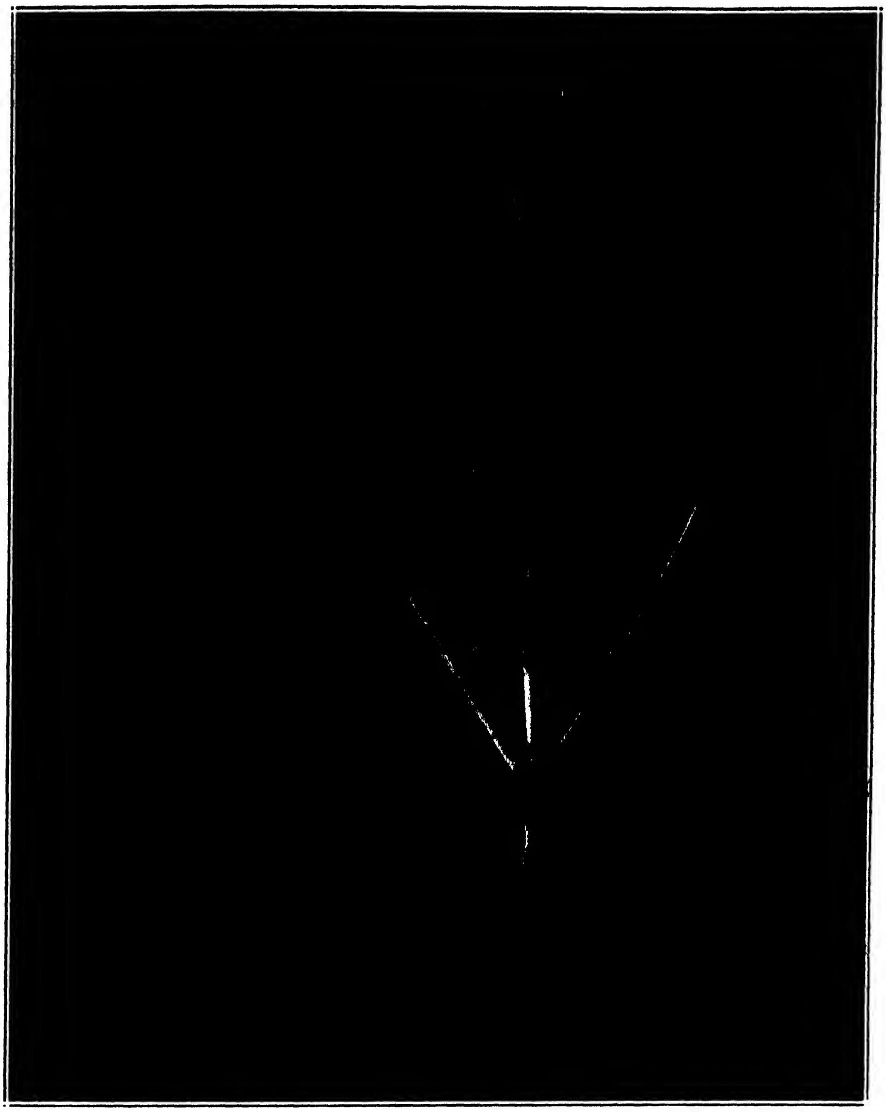
Discussion.

Of the many plants that have been grown in insect-proof cages during the past year, not a single one has taken Mosaic disease unless it was exposed to insects. During all of this time there has been more or less spread of mosaic to cane and corn grown in small garden plots a short distance from the cages. There seems to be good evidence that the spread of mosaic in the fields is by insects. At the present time the corn aphid is the only insect known to carry mosaic to cane. It is fortunate that the cane aphid and cane leafhopper do not carry the disease. The corn leafhopper carries mosaic from corn to corn, but does not seem able to carry it from corn to cane or from cane to cane. Brandes [5] found that corn aphids can transfer mosaic from cane to sorghum and from sorghum to corn. His results indicate that the mosaic of cane is identical with that of sorghum and corn. If these diseases are identical it is rather strange that the corn leafhopper, which so readily transfers corn mosaic to corn, is unable to transfer it to cane. This insect is chiefly responsible for the spread of mosaic in the corn fields of Hawaii.

It seems improbable that the corn aphid is the only insect that takes part in the spread of mosaic to healthy sugar cane fields. Further experiments are expected to show that other insects are able to carry the disease to cane. It is interesting to note that the corn aphid does not thrive on sugar cane. It cannot, in fact, maintain a colony on this plant. In the experience of the writer, eleven days is the longest period of time that any corn aphids have been able to live on cane plants. Most of them die after one week. It is not believed that this insect can invade cane fields to such an extent as to be of any importance in the spread of mosaic from diseased to healthy cane. If, however, a suitable host plant subject to the same mosaic disease is present in or near cane fields, this aphid may become a serious means of spreading the disease. During the past year it was observed that mosaic had spread very rapidly in a field of young plant cane. On examination it was found that goose grass *(Eleusine indica* Gaertn.) was growing as a weed in this field. The grass was quite generally infested with corn aphids* and some of the plants had mosaic disease. Shortly before the spread of mosaic to the cane, most of the goose grass had been cut in an effort to clear the field of weeds. It is believed that in this instance the corn aphids went onto the cane when the grass was cut. In so doing they probably carried the disease from the grass to the cane. Some of the worst epidemics of Yellow Stripe have occurred in cane fields adjoining or near corn fields. It is probable that at least a part of the spread in these fields can be attributed to the corn aphid.

Although the corn aphid is not classed as a cane parasite in Hawaii, it has been reported on this plant in Java, and in a recent letter Dr. Brandes states: "I myself have seen it on sugar cane in the fields of Georgia and can assure you that under greenhouse conditions in Washington it is sometimes so abundant as to almost cover young plants." The observations of Dr. Brandes sug-

* The aphids were identified by H. T. Osborn of the Department of Entomology of the Experiment Station of the H. S. P. A.



Goose grass, a weed that is subject to mosaic and harbors the corn aphid.

gest that the strain of *Aphis maidis* in the greenhouses at Washington and in the fields of Georgia is different from the one present in Hawaii.

The exact number of weeds and grasses on which this insect flourishes is not definitely known. It doubtless lives on many plants on which it has not yet been reported. It is known to breed on the following plants: Corn, sorghum, broom corn, barley, wood sorrel *(Oxalis* sp.), foxtail *(Setaria glauca* (L) Beaw.), panic grasses *(Panicum crus-galli* L., *P. sanguinale* Seem., *P. dichotomiflorum* Michx.), knotweed *(Polygonum pennsylvanicum* L.[7]), goose grass *(Eleusine indica* Gaertn.), and the club rush *(Scirpus maritimus* L.)* It is probable that the mosaic occurring on some of these grasses is identical with cane mosaic. Brandes[5] has shown that the mosaic on cane is the same as that on sorghum by transferring

* Otto H. Swezey found corn aphids on the club rush in Kapiolani Park, Honolulu.

the disease from cane to sorghum. In discussing other host plants he says: "With regard to sorghum, crab-grass, foxtail and Panicum our evidence is conclusive and proves that the infectious material or virus is the same for all of these plants." [4]

Mosaic is known to occur in Hawaii on the following plants belonging in the grass family: Sugar cane, sorghum, corn, Sudan grass, wonder forage grass (*Andropogon* sp.) and goose grass.

All crops that harbor the corn aphid and all grasses subject to mosaic disease should be grown at some distance from sugar cane fields. Keeping fields free from weeds and wild grasses is to be recommended, not only because this is good agricultural practice, but because it will help to prevent the spread of the Yellow Stripe disease.

Summary.

1. The corn aphid can transfer the Yellow Stripe disease to cane.
2. Experimental evidence indicates that the cane aphid and the cane leafhopper do not carry the disease.
3. The corn leafhopper readily transfers mosaic from diseased to healthy corn plants, but is unable to carry it from cane to cane or from corn to cane.

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Direct and Indirect Injury to Plants by Insects.

By F. Muir.

The injury done to plants by insects is of two kinds, direct and indirect. In the former case it is purely mechanical, such as eating the leaves, stems or roots or by sucking the juices The borer and anomala beetles and the leafhopper are examples of such injury. In the case of indirect injury the mechanical harm done is very slight, the chief damage being done by foreign bodies being introduced into the plant by the insects. The mosaic disease is an example of this.

In the early days of economic entomology, attention was concerned solely with direct injury. and even today our greatest efforts are being made to counteract such injuries. But as knowledge of plant diseases has increased it has been found that insects play an important role in their distribution, even as some insects have been found to carry diseases between man and man, and between various animals and birds. As carriers of diseases, the insects act in two manners. They can form an intermediate host in which the parasite undergoes part of its life cycle, and without such a host it is unable to extend the boundaries of its activities; the malaria parasite and the mosquito is such a case. Or they can act purely as mechanical carriers and simply convey the disease from one party to another without the parasite undergoing any part of its life cycle during the period of transition. As simple carriers they can form a reservoir in which the parasites live (generally internally) for long periods, but undergo no transformation, or they can simply convey them externally on their mouth organs or body.

The method of conveyance is of great economic importance, for intermediate hosts and reservoirs when once infected carry the disease over long periods and inoculate many victims, whereas the simple carrier can carry the disease only for a limited period after being contaminated and can inoculate only a very limited number of victims.

Fighting an insect that does direct damage is generally a simpler matter than fighting one that does indirect damage. By the introduction of beneficial insects into our cane fields we have reduced the damage done by directly injurious insects to such a point that their damage is relatively small; but if they had been indirectly injurious insects I doubt if the reduction would have been great enough to produce very beneficial results. As an example I can cite the leafhopper, which has been reduced to such a degree that it now does no injury except in one or two comparatively small areas. But if it were a carrier of a disease, such as mosaic, then the present reduction would not be sufficient to be very beneficial. One or two leafhoppers on a stool of cane could do no direct injury, but a single leafhopper conveying a disease would be enough to infect the cane.

Thus we see that the control of directly injurious insects is a very different problem to the control of an indirectly injurious insect, and generally a more simple task.

In Hawaii, mosaic disease is not nearly such a serious disease as in Porto Rico, and it would be of great interest to know why this is so. At present it looks as if this may be due to certain insects in Porto Rico which convey the

disease directly from diseased sugar cane plants to healthy sugar cane plants, whereas all of Dr. L. O. Kunkel's experiments indicate that we have no such insects in Hawaii. and the only conveyors are occasional visitors to the cane plants. There is another possibility, that a disease becomes more virulent if conveyed by one insect than it is when conveyed by another insect. There is an indication that this is so in malaria when conveyed by different species of mosquitoes.

In Trinidad the damage done by the Cercopid leafhopper is not by the young feeding upon the roots, but by the adults which feed upon the leaves and cause them to die. From published colored plates of affected leaves it looks as if the leafhoppers conveyed a disease to, or injected a poison into, the leaves. The spot where they puncture the leaf to suck the juice (in a similar manner to our sugar cane leafhopper) becomes discolored and dies. The dead area increases very rapidly and soon the whole leaf is dead. Experiments have been made to see if this was the cause of the stunted growth. All the larger leaves were stripped from cane plants and this was found to cause the same stunting of growth as when the leaves were killed by leafhopper attacks. It is therefore possible that the Trinidad leafhopper is indirectly injurious.

This all demonstrates the necessity of keeping out all insects from our islands, except those whose beneficial natures have been fully demonstrated, for an apparently harmless insect may be a conveyor of diseases. It also demonstrates the necessity of using the utmost care should canes be brought into the Territory, for they may contain the germs of a disease which insects already in the Territory may be capable of conveying.

On account of their method of feeding, the Homopter, or leafhoppers, plant-lice, jumping plant-lice, scales and mealy bugs, are the most liable to be conveyors of diseases, and on this account their economic importance becomes greater than suspected until recently.

Field Methods Used at Waipio.

One of the plantations asks the following questions concerning the methods used to produce the field of cane at Waipio inspected in December by those in attendance at the annual meeting of the Association:

1. When was this field last harvested?
2. How long was the water off this field prior to harvesting?
3. How many months prior to harvesting was the last application of fertilizer made?
4. After harvesting, when was the first application of water made, and how much in acre-inches?
5. How often were subsequent applications of water made, and the amounts in acre-inches?
6. Dates of all fertilizer applications, amounts, and the chemical analysis of fertilizers?
7. Analysis of the soil as to potash, phosphoric acid and nitrogen content prior to first application of fertilizer for this crop?
8. When will this field be harvested this year?
9. Do you intend to carry out the same program for next crop?
10. When this field was planted, kindly give date, space of seed with relation one to the other, and kind of seed; that is, body, top, etc.
11. For first ratoons, how much re-planting was necessary?
12. How much weeding was done in this field?
13. Any other data you may think we may be interested in.

The following answers to these questions have been drafted by J. A. Verret, who has had supervision of this work at Waipio:

1. The last crop (plant cane) was harvested in late May and early June, 1920.
2. The last irrigation was started on January 8, 1920.

   From January to May we had the following rainfall:

January, 1920	6.68	inches
February, 1920	.72	"
March, 1920	4.58	"
April, 1920	.72	"
May, 1920	1.67	"

   For best results at Waipio the water should be taken off from 60 to 90 days before harvest, depending on how fast the field dries out.

3. The last application of fertilizer, consisting of 650 lbs. of nitrate of soda, was made one year before harvest, in May, 1919.
4. It is our policy to put on the first water as soon behind the cutters as possible. We do not wait until the whole field is harvested before starting, but as soon as a level ditch is cleared we irrigate that part. This is generally within a week after cutting.
5. The average irrigation interval was 20 days. In the hot, dry summer months we endeavor to make the rounds every 15 to 16 days. From December, 1920, to February, 1921, there was no irrigation for a period of 74 days on account of rain.
6. The plant crop, harvested in 1920, was fertilized as follows in pounds per acre:

   450 pounds ammonium sulfate on August 12, 1918.
   580 pounds nitrate of soda on October 24, 1918.
   650 pounds nitrate of soda on May 29, 1919.

   This supplied 280 pounds of nitrogen per acre.

The present ratoon crop was fertilized as follows:

667 pounds of nitrate of soda on July 1, 1920.

666 pounds of nitrate of soda on September 20, 1920.

400 pounds of acid phosphate on September 20, 1920.

666 pounds of nitrate of soda on February 11, 1921.

This amounts to 310 pounds of nitrogen per acre.

7. The following is the analysis of the soil from this field:

Total acid soluble potash (K_2O)=.25%.

Total acid soluble phos. acid (P_2O_5)=.33%.

Total citrate soluble phos. acid=.003%.

Total nitrogen=.13%.

8. This field will be harvested again next April or May, this to depend on the time of the winter rains.

9. The next crop will be a short ratoon to be harvested about August, 1923. The treatment will be about the same, except that probably slightly less nitrogen will be used, about 280 to 290 pounds per acre.

10. The field was planted in May and June, 1918, and was not cut back. Top seed was used, lapped about one inch. Small poor seed pieces were discarded.

11. There was practically no replant needed in the first ratoons. This is fortunate, as with this system of quickly starting the new crop, the replant has no chance to come through unless done very early. What replanting is to be done we now endeavor to do with the first water. We go over the field very carefully and fill in gaps and missing stools. In this way the seed comes up almost as soon as the ratoons, and is not choked out as is the case if replanting is delayed until the ratoons have made some growth.

12. We have no charges for weeding against this field. What few weeds came up were easily taken care of by the irrigators without slowing down the irrigating. With the heavy growth of cane, weeds have no chance to mature seeds, so the only weeds we have to contend with are those from the few seeds coming down with the water.

13. We do not cut back at Waipio. The cane is kept growing as fast as possible, more particularly during August and September every effort is made to see that it suffers no check. We have at present a field of about 10 acres in short ratoons, from cane cut last April. We have been able to find but three tassels on this field. This area has been fertilized as follows:

June 1, 1921—810 pounds nitrate of soda.

June 1, 1921—350 pounds of acid phosphate.

August 5, 1921—810 pounds of nitrate of soda.

The average time of an irrigation round has been 17 days (not including the rainy season). The field has had no cultivation or weeding of any kind. We estimate 9 or 10 tons of sugar at harvest next August.

We employ at Waipio a system of handling our fields, developed by Mr. Verret, which is designed to take full value of the available area and growing time. There follows his description of this system.

We endeavor always to have two-thirds of the area in long ratoons or plant, and one-third in short ratoons. Each year we harvest two-thirds of our total area, one-half of which is long ratoons or plant and one-half short.

In harvesting we begin with the long ratoons, finishing about June. All these fields then go into short ratoons for the next crop. We then harvest the short ratoons, these fields in turn becoming long ratoons for the crop two years hence. In this way no cut back is needed. We obtain two crops in three years, the average cane being 18 months old at harvest, none of which should ever be over two years old or less than 16 months. In this way we attempt to obtain the utmost returns from the land by doing away with idle time.

Last year we obtained 0.553 tons of sugar per acre per month from our plant and long ratoons, so if we lose a month's growing time we lose that much sugar. This amounts

to 37 pounds of sugar per day per acre. At four cents a pound that gives a "growing time" value of $1.48 per day per acre.

We feel that such success as has thus far been attained at Waipio in producing high yields of cane is due in part to this practice of placing a potential money-value or sugar-value on each acre-day or acre-month. In first proposing sugar-per-acre-per-month as a standard for comparing yields, in the annual report of the Station for 1918, we had this to say:

> In comparing cane yields, the length of the growing season often varies to such an extent as to make the usual standard of tons-of-sugar-per-acre a deceptive one. We have recently found much of interest in comparing our cane yields at the Waipio substation on a basis of tons-of-sugar-per-acre-per-month. The correct way to employ this standard is to throw all idle time and all growing time prior to cutting back into the period of the succeeding crop, as this gives a value to this lost time and works toward reducing it to a minimum. On plantations where land is abundant and there is opportunity to fallow, the proposed standard of comparison has not the advantage that it will have on plantations which practice intensive cultivation and desire to make the most of every area of land during every month in the year.
>
> With the knowledge, for instance, that a piece of land may produce sugar at the rate of .3 to .4 ton of sugar per acre, a single acre of land assumes a value potentially of a gross return of about one dollar per day, and lost time in getting a new crop under way can be rated accordingly. Such an estimate applies to the average of the whole year, but lost time in an active growing period assumes an enhanced valuation.
>
> The system also offers an opportunity of deciding accurately between the merits of long cropping and short cropping. A field yielding 4.4 tons of sugar during an 11-month period is producing sugar at the same rate as a field which produced 10.8 tons of sugar in 27 months, though at first glance we are apt to think that one is a poor yield and the other a very excellent one.

It is interesting to observe that in giving an illustration of this system of measuring yields three years ago, we considered .3 or .4 ton-per-acre-per-month a satisfactory realization and gave .48 as the maximum attained. At that time we looked on .5 as a goal to achieve.

In recently reporting the 1921 yields at Waipio, the developments of three years' time are reflected in yield figures that show an average of .553, a maximum of .664, and a minimum of .383.* A yield that was satisfactory three years ago would today be ample cause for an investigation.

While fertilizers and field methods, *per se*, have played an important part in these better yields, such agents could not have been employed to the same advantage without the attitude toward sugar production that gives a full consideration to the potential value of the acre-day. If this amounts to 37 pounds of sugar, all operations must be so regulated that 37 pounds will be realized in practice. Fertilization, irrigation, and other procedures must take place on schedule time. If some neglect must occur through adverse circumstances, such as a shortage of labor. we let it occur where it has the least effect on the potential production per acre-day. Careful estimations are required to determine such a point. This is one of many things that will make close technical supervision of all plantation operations a very profitable undertaking once its merits are recognized.

H. P. A.

* Part of this area was not fertilized.

Notes on Irrigation at the Waipio Substation.

By J. A. Verret.

The impression prevails in some quarters that to produce the rather large yields of cane reported from Waipio, great amounts of water are used.

It was therefore thought that it would be of interest to report on the exact amounts of water used to produce the 1921 crop at Waipio.

These figures are given in the following table:

Field	Irrigation Intervals — Days	Total Acre Inches per Acre	Acre Inches per Acre per Irrigation
A, L. Ratoons..............	21	98	4.7
B, " "	20	138	6.6
C, " "	21	101	5.0
D, " "	21	145	6.9
E, " "	20	137	6.5
F, " "	20	140	6.7
G, " "	21	122	5.8
H, " "	19	118	5.6
I, " "	21	131	5.9
S, " "	21	129	5.9
U, " "	22	133	6.0
V, " "	22	119	5.7
No. 27, "	21	129	6.2
T, Plant	17	132	4.6
No. 19, Plant	16	199	6.8
No. 37, S. Ratoon	..	85	...
Average	20	139	5.9
Rainfall	..	48	
Total	..	187	

Total water used = 21,073 tons per acre.
Sugar produced = 9.85 tons per acre.
Tons of water per ton of sugar = *2,140.*

Experiment A, given above, was an irrigation test where part of the area was irrigated every other line. That accounts for the smaller amount of water used.

From the above table we find that the average interval between irrigations was 20 days. This interval varies to some extent with the season. In the warm, fast growing periods we make the intervals somewhat shorter, while in winter they are longer. The 20-day interval given above does not include periods when there is no irrigation on account of rain.

The total irrigation water used amounted to 139 inches, the rainfall was 48 inches, making a total of 187 acre inches per acre for the crop.

The average amount of water applied per acre per irrigation is found to be 5.9 acre inches. This is slightly more than the amount actually used per regular irrigation as it includes "dry spot" irrigation.

A number of our fields contain pali's which dry out faster than the other areas. These dry spots receive extra irrigations.

The total water used amounted to 21,073 tons per acre. The average yield of sugar was 9.85 tons per acre. The tons of water per ton of sugar was 2,140.

In reports read at the annual meetings at different times and including plantations on Oahu, Maui, and Kauai, the average tons of water per ton of sugar is given as 3,898, which is almost twice the amount used at Waipio.

The water at Waipio is measured as it leaves the reservoir by means of a venturi meter. This meter has been carefully tested and is accurate. The seepage from the reservoir is also included.

Value of the Upper Joints of Cane.

By W. L. McCleery.

It is known that the top of sugar cane contains less sucrose and more impurities than the lower portions, though there seem to be few data regarding the manufacturing value of the upper joints, from which conclusions can be drawn as to the proper point for topping. There is apparently no information available concerning a common point of identification near the top of the stalks which is easily recognizable and that can be applied to all sticks of cane.

Brown and Blouin, in Louisiana Experiment Station, Bulletin No. 91, report decreased coefficients of purity and increased amounts of glucose in the juices obtained from succeeding joints of cane starting from the butt toward the top.

Dr. Norris, in the Hawaiian Planters' Record III, 128, gives results of some work done at this Station. Samples of cane were selected which had been topped so that about six or eight inches of the green leaves were left on the stalks. In each sample the top, including the first joint below the green leaves, was separated from the rest of the stalk, and the juices from the two portions analyzed separately. The average of five tests showed:

	Brix	Polarization	Purity
Top	9.1	4.8	52.7
Remainder	18.0	16.4	91.1

In all of the above work the juices were extracted under varying conditions, and no data are given as to pressure applied, nor information correlating the juice purities with the normal juice. It was therefore thought advisable to make a larger number of determinations in order to have as much information at hand as possible

The greatest difficulty about an investigation of this kind is to find a reference mark which is strictly comparable and capable of duplication with all sticks of cane. After examining a number of sticks it was noticed on each,

that the first leaf tightly wrapped for the full length of its sheath was attached to the node above the joint, which for the lack of a better expression we have termed the *last weathered joint.* The leaf growing from the lower node of this joint having started to separate has allowed it to become weathered and assume an appearance of maturity. While this point is not all that could be desired as a reference mark, it seems to be fairly capable of being duplicated on all stalks of cane. This point can also be recognized on burned cane, as the tightly wrapped green leaves are not affected by the fire.

The accompanying illustration shows one cane top, A, with the leaves removed. B is a top with the leaves removed to the lowest tightly wrapped leaf. C shows the sections made by cuts at the center of the different nodes. The last weathered joint described above lies between the figures two and three, and has a white thread tied around its center in both A and B.

As a preliminary experiment, 29 sticks of H 109 cane grown at the Experiment Station were used, large, small and medium sized sticks being included. Cuts were made at points indicated by lines in the illustration. The joints taken for analysis were those opposite Nos. 1, 2, 3 and 4. The adhering leaves were included in the samples. It will be noted that Samples 1 and 2 were below the center of the last weathered joint, and 3 and 4 above.

The samples were chopped very fine so that the largest pieces were not over a quarter inch in diameter. They were then placed in bags and the juice expressed under about 1200 lbs. pressure per square inch. The analyses made included Brix, polarization, sucrose, glucose and ash on the expressed juice, and fiber, moisture and polarization on the residual cake. Records were made of weights on all samples so that the analysis of the original cane could be reconstructed. The stalks below sample No. 1 were ground in a small mill, expressing about 50% of the juice. Following are the analyses:

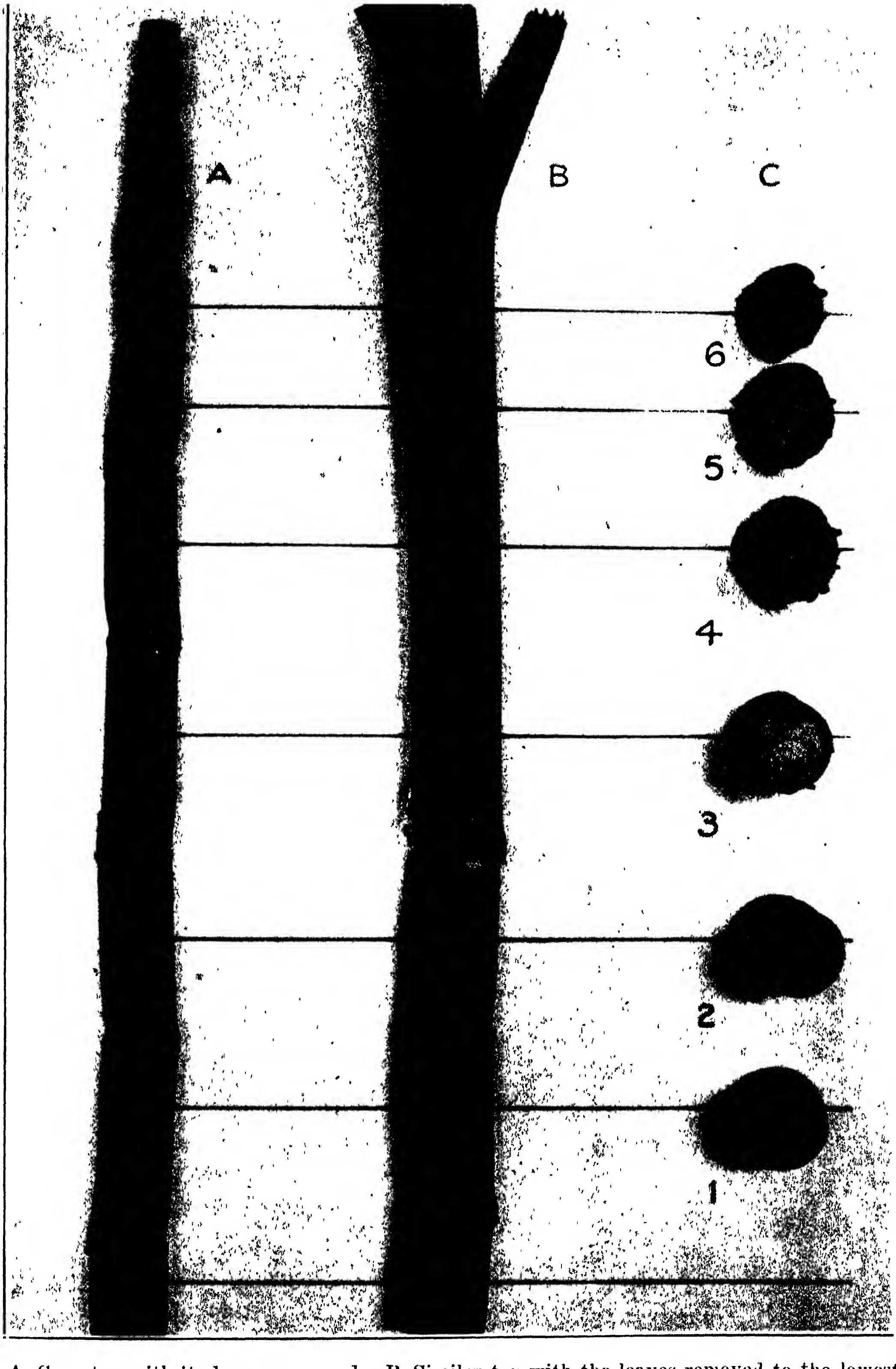
JUICE

Joint	Brix	Ap. Pur.	Gr. Pur.	Glucose	Ash	Juice % Cane	Juice % Juice	Glucose to Ash	Sucrose to Ash
No. 0 ..	21.4	91.8	....	....	....	....	....	....	.....
No. 1 ..	19.4	80.2	81.4	1.05	0.82	73.5	81.9	1.28	19.29
No. 2 ..	18.0	73.8	75.3	1.42	0.93	75.0	83.3	1.53	14.58
No. 3 ..	16.0	66.6	68.9	1.76	1.11	75.0	83.4	1.59	9.92
No. 4 ..	14.1	56.1	58.1	2.10	1.33	75.0	83.3	1.58	6.16

"0" is the juice from the remainder of the stalks below joint No. 1.

RESIDUAL CAKE

Joint	Per Cent	Pol.	Fiber	Moisture	Solids Not Pol.	Pur. Residual Juice
No. 1	26.5	8.6	38.7	50.0	2.7	76.1
No. 2	25.0	7.7	39.8	50.0	2.5	75.5
No. 3	25.0	6.4	40.2	50.7	2.7	70.3
No. 4	25.0	5.2	40.0	50.9	3.9	57.1



A, Cane top with its leaves removed. B, Similar top with the leaves removed to the lowest tightly wrapped leaf. C, Sections made by cuts at the centers of the different internodes.

CANE ANALYSIS CALCULATED FROM ABOVE DATA

Joint	Sucrose	Fiber	Normal Juice			
			Brix	Pol.	Ap. Pur.	Gr. Pur.*
No. 1	13.9	10.3	19.3	15.3	79.5	80.6
No. 2	12.1	10.0	17.8	13.2	74.1	75.3
No. 3	9.9	10.1	15.9	10.7	67.2	69.4
No. 4	7.4	10.0	14.3	8.0	56.3	57.9

* The apparent and gravity purity of the juice left in the cake was assumed to be identical. No appreciable error is introduced by using this figure.

In applying the S. J M. formula to these results the writer has used the gravity purity of normal juice and assumed a final molasses of 37 gravity purity. This the writer believed to be conservative, for it will be noted that the purity used is the gravity purity of the normal juice and not that of the expressed juice. Under factory conditions the purity of the juice recovered should be somewhat higher than the normal juice purity. The above assumption makes no allowance for increase of purity during clarification. Such an increase might reasonably be expected. In the joints where the purity is lowest the glucose is high, a factor which favors the production of low purity molasses. With the assumption indicated above, using the S. J. M. formula the following percentages of total sucrose are recoverable

Joint No. 1	85.9%	Joint No. 3	74.2%
" " 2	80.8%	" " 4	57.4%

The weight of the topped cane was 52.25 lbs. The following table shows the percentage the different samples bore to the weight of topped cane, and also the percentage the recoverable sucrose in different joints bears to the recoverable sucrose in the cane.

Joint No.	Weight	Per Cent	Total Sucrose	Recoverable Sucrose	Per Cent Recoverable
Stalks	52.25 lbs.	100	8.10 lbs.		
1	2.75	5.26	0.38	0.32	4.0
2	2.50	4.78	.30	.23	2.8
3	2.30	4.40	.23	.16	2.0
4	2.05	3.92	.15	.09	1.1

The amount of recoverable sugar decreases very rapidly in the succeeding portions of cane examined; nevertheless the highest joint examined (No. 4 in the illustration) contains juice capable of at least as high a recovery as No. 2 massecuite. In this case the recoverable sugar in this joint amounted to over 1% of the recoverable sugar in the cane. From a manufacturing standpoint such material as in joint No. 4 is valuable, though the extra recovery is not net gain, for there are harvesting and transportation charges also to be assessed against it.

The above investigation covers but a single case, and that rather incompletely, for it would be desirable to also have the analyses of joints Nos. 5 and 6. When this experiment was started it was expected that data on joints 1 to 4 would cover all information desired.

While this work can only be considered as preliminary, the calculations show these upper joints to be more valuable than they are usually considered. The writer believes it most desirable to investigate this subject thoroughly, particularly as the "last weathered joint" as described above appears to furnish a satisfactory reference point for such an investigation.

Bud Selection and Increased Yields.

By A. D. Shamel.

A very striking instance of the importance of bud selection as a means for increasing crop yields has recently come to the writer's attention. It is one of a constantly increasing number of illustrations which demonstrate and prove beyond all question of doubt the practical value of bud selection work for increasing and improving the yield of all plants which are propagated vegetatively.

The Canadian Agricultural Experiment Station began many years ago a variety test of apples at the Central Experiment Farm, Ottawa. The variety orchard contained a few trees each of a large number of varieties. The purpose of the experiment was to determine whether or not any of the varieties tried would be adapted for commercial apple production in eastern Canada.

In 1906 individual tree records of yields of production were begun in the variety orchard as a means for securing definite evidence as to the value, if any, of the varieties for commercial propagation. The Wealthy variety was found to be the only one which seemed to possess the essential qualifications for commercial production. Of the trees in the orchard of this variety, three were found to have characteristic yielding habits.

The three Wealthy trees were normal, healthy, and possessed the same vegetative and fruit strain characteristics. As a result of eight years of individual tree performance records it was found that one of them produced comparatively high yields, one characteristically regular annual yields, and one consistently low yields. In other words, of the three Wealthy trees one produced the greatest total crop, one a somewhat lighter yield than the heaviest producer but more regular crops, while the third produced a low total yield. The total yields of the three Wealthy trees for a period of eight years was as follows:

Heaviest yielding	104¾	gallons *
Regular yielding	78¾	gallons
Poorest yielding	41	gallons

* The unit of measurement used in these performance records was the English dry gallon which contains one-eighth of a bushel.

It should be borne in mind that there were no apparent strain differences in the three Wealthy trees. The only difference observed, except yield, was the somewhat smaller size of the low yielding tree. The foliage and fruit characteristics were the same so far as anyone could see them.

In 1906 scions were taken from each of the three parent Wealthy trees. The scions from the high yielding tree were root grafted upon stock which had been carefully selected as to size and other physical characteristics. The scions from the most regular bearing tree were similarly root grafted to those of the high yielding tree. The scions from the low yielding tree were root grafted in the same way as those from the other parent trees. Twenty-five scions from each tree were root grafted and the whole lot set out on as uniform land as it was possible to find at the experiment station farm. These young trees constituted a progeny planting. The purpose of this progeny test was to discover whether or not the yielding power of the three parent Wealthy trees was transmitted through budding. This progeny planting arrangement is similar in some respects to the present progeny cane fields on the sugar plantations in the Hawaiian Islands.

When the writer first learned of the Canadian apple bud selection study, late in the summer of 1912, he immediately went to Ottawa in order to study the conditions at first hand. The horticulturist, W. T. Macoun, very kindly showed the writer the parent trees, the progeny planting, and all of the records in this investigation.

It was found that the parent trees were located in the variety orchard as neighboring trees, but upon rather uneven or ridged land. The question immediately arose as to whether the differences in their yields were due to differences in the local soil or environmental conditions, or were the result of inherent influences. The only way by which this question could be solved was through the progeny test.

The young progeny trees were not in full bearing at the time of the writer's visit to the Ottawa Experimental Farm. However, some differences in the behavior of the young progenies were noticed which indicated that inherent differences existed in these progenies. The progeny trees from the low yielding parent tree were smaller than those of the other progenies. The progeny trees from the two high yielding parent trees had begun to bear fruit, while those from the low yielding parent tree had not begun to produce apples. The strain characteristics of the young trees in all three progenies were the same so far as the writer or his host could discover.

In the December, 1921, issue of Scientific Agriculture, the official organ of the Canadian Society of Technical Agriculturists, M. B. Davis, Assistant Horticulturist of the Central Experimental Farm, Ottawa, presents a report of the behavior of the progenies of the three parent Wealthy apple trees. A brief summary of this report is presented in order to show the facts in this investigation. It is not possible here to give the full details as shown in the report, but enough data will be presented to show the important discoveries of this conclusive study.

TABLE SHOWING RANK OF PARENT TREES AND RANK AND YIELD OF PROGENIES FOR A PERIOD OF NINE YEARS

Rank of Parent Trees	Rank of Progeny Trees	Yield of Progeny Trees
Heaviest yielding	Heaviest yielding	57.18 gallons
Most regular yielding ..	Most regular yielding ..	48.38 gallons
Poorest yielding	Poorest yielding	35.22 gallons

In addition to the very significant and important facts as shown in the above table, it should also be stated that the prognies differed very markedly in their ability to survive under the very adverse climatic conditions at Ottawa. This point is also of particular significance in connection with our sugar progeny work in Hawaii.

Of the original 25 trees in the progeny from the heavy yielding parent tree, 17 survived. Of the 25 progeny trees from the most regular bearing parent tree, 12 survived. Of the 25 progeny trees from the poorest yielding parent tree, 8 survived. In other words, the progenies from the most productive parent trees survived best under the stress of adverse environmental conditions.

In order to eliminate root stock influence, a second experiment was carried on during the same period as the first study. In this experiment scions from each of the three parent Wealthy trees were top-worked upon a large Russian tree. In this case all three parents were grown upon the same individual stock. Five top-worked trees were used in this experiment, the positions of the scions in each case being changed in order that on the different top-worked trees all of the progenies would have the same exposure to light, wind, etc.

The results of this progeny test were even more striking than those shown for the first or root-grafted progeny test. The differences between the yields of the progenies from the heavy producing parent trees and that of the progeny from the poor yielding parent tree were much greater than the results shown for the root grafted progeny trees.

These results, in a fruit that some horticulturists have said was an exception to the general rule in response to bud selection work, are of exceptional and valued importance to everyone interested in this work. They demonstrate undisputably the practical importance of bud selection and progeny work as a means for improving yields.

In sugar cane the number of stalks in a stool may be roughly compared to the number of fruit bearing branches in the apple trees in the experiment just described. In other words, in both cases it is a question of quantity. The apple study shows that quantity of fruit is an inherent character. The writer believes that in sugar cane the quantity of stalks in a stool, or the amount of sugar in the stalks, are inherent characters. In the studies with stool selections in sugar cane now being carried on by the Experiment Station of the Hawaiian Sugar Planters' Association there is abundant evidence to support this belief.

Furthermore, in our sugar cane bud selection studies we have found definite strain characteristics and have isolated strains in each of the varieties under investigation through bud selection. With this fact in mind and considering the wide range for the selection of parent stools, as compared with the limited number of parent apple trees to select from, may we not expect even much greater results than were found in the Canadian apple study?

Fig Trees for Hawaiian Forests.

By H. L. Lyon.

It is now quite unnecessary for us to call the attention of any agriculturist in Hawaii to the fact that our native forests are rapidly disappearing and that our watersheds are already bare in many places. It may be held a certainty that if sugar cane culture is to be continued in these Islands on the scale which it has now attained, existing forests must be rehabilitated and additional forests created, for if suitable blankets of vegetation are not maintained on our important watersheds they will fail to yield the constant supply of water which our agricultural projects demand.

Adequate protection of our native forests will serve to prolong their existence, but cannot keep them with us indefinitely. There are natural and uncontrollable factors now operating which will eventually eliminate the native forest trees, or at least reduce their numbers to such an extent that they will no longer constitute an adequate forest cover. The only method of procedure therefore by which we can hope to rehabilitate our old forests and create new forests is to plant introduced trees which will be able to thrive and spread in spite of the opposing factors which are proving too strong for our native forest trees.

All forest planting on the uplands in these Islands will be done for one of two purposes, either to secure trees for commercial timber, or to secure trees for watershed cover and the conservation of moisture. Watershed areas which must be reforested for water conservation only, are far more extensive than the areas suitable for commercial plantings. Due to the very broken condition of our watersheds it would cost more to get the timber out of most sections than it would be worth, and so it is quite out of the question from a practical standpoint to make commercial timber lots out of our watersheds. If we should once get them covered with good commercial timber, its value in conserving water would be so great that we could not afford to cut it off, denuding our watersheds and jeopardizing our water supply. The water-conserving properties of a good forest cover on our watersheds is of far greater value to us than any crop of commercial timber that we can possibly grow on these watersheds. It seems, therefore, that in selecting trees to cover our watersheds we do not need to select species fulfilling any requirements other than that they will become components of a suitable water-conserving forest.

The most casual consideration of our forestry problem will show that we cannot hope to cover all of the denuded areas by planting out the necessary

number of trees one by one. A procedure of this sort would require unlimited time, labor and money, and we cannot afford to concede any of these to our program. Our first aim therefore has been to find trees which not only promise to become suitable components of cur rain-forests, but which at the same time show capabilities of being spread by natural agencies, such as wind, water, and birds. To enlist such trees in our reforestation work we have but to plant groups of each species at intervals on our watersheds, and as soon as the trees reach the fruiting stage they will be spread by natural forces without further attention from us.

In order to secure the forest conditions which we desire over all of our watersheds we must reforest areas presenting two distinct conditions: first, areas which are quite denuded of forest cover, and second, areas which still carry a decrepit native forest. In seeking trees which will be spread by natural agencies under the existing conditions we must find some trees which will spread in the open areas and other trees which will spread in the areas still partially covered by forests.

In searching for trees which fulfill all of the requirements enumerated above we have reached the conclusion that many species of the very large genus *Ficus* can be relied upon to accomplish much in the building of new forests and the revivification of the old forests on our watersheds. There are over 600 known species of *Ficus* or fig trees, which are widely distributed throughout all the tropical regions of the globe. It is most remarkable that no species of fig was a natural immigrant to these Islands, for there are many species in Central and South America and a very large number in Australia and on the Asiatic continent. Most of the progenitors of our native plants were immigrants from these continental regions and it seems remarkable that trees so well adapted to long migrations as are the figs did not become established here in early times. They did migrate to most of the tropical islands in the Pacific, and we find many species endemic in the Fijis and Samoa, while the little island of Guam is blessed with several species. It may be that they did arrive here, but that their natural reproduction and distribution was prevented by the non-arrival of the specific insects which are essential to their seed production. Had one or more species of figs become established in these Islands in early times it is safe to say that we would not have to deal with the serious forest problems which now confront us.

Seed Production and Dissemination in Ficus.

All species of *Ficus* have a very highly specialized mechanism for the production and dissemination of their seeds, but the operation of this mechanism is only possible through the assistance of certain wasps whose reproduction is intimately associated with and dependent upon the seed production of the fig plant. There is a particular species of wasp associated with each species of fig, the wasps from one species not being able to operate the seed producing mechanism of another species of fig.

The minute flowers of the fig are produced within a closed receptacle which eventually becomes the fleshy body commonly called a fig. The flowers are always unisexual, the male and female apparatus being produced in different

Fif 1. *Ficus macrophylla.* A young tree of the Moreton Bay fig growing at Puuomalei on Maui.

flowers which are in some species located in different receptacles. When male and female flowers are produced in the same receptacle they do not mature at the same time, and consequently pollenation of a female flower can be effected only by pollen coming from some other receptacle. The transfer of the pollen from one receptacle to another is accomplished by the wasps, which are in reality parasites of the fig as they breed in the fig flowers. The female flowers in a receptacle mature while the receptacle is quite small. The female fig wasps enter these small receptacles and deposit their eggs in many of the female flowers. These eggs hatch and the wasp grubs obtain their nourishment from the ovary of the flower. Eventually these grubs pupate and come out into the receptacle as mature insects. These newly emerged wasps mate while they are still in the receptacle, then the females bore their way out and migrate to young receptacles on the same tree or another tree, where they seek female flowers in which to deposit their eggs. While the female flowers in a receptacle mature at the time the wasps enter, the male flowers in the same receptacle mature when the new generation of wasps are leaving the receptacle. As the female wasps move about in the receptacle before leaving it they become covered with pollen from the recently matured male flowers and consequently when they enter a new receptacle they are covered with pollen which becomes distributed on the stigmas of many of the female flowers and brings about their fertilization. Hence while young wasps are developing in the ovaries of some of the female

flowers, seeds are developing in the ovaries of other female flowers in the same receptacle.

Under such an arrangement one might expect that in some receptacles the wasps would deposit eggs in all of the female flowers and consequently there would be no chance for seed development. The wasps may actually try to lay their eggs in all of the female flowers in a receptacle, but the fig plant insures that the insect will not succeed in this attempt by producing two types of female flowers, one with short styles and the other with long styles. In depositing its egg in a female flower a wasp thrusts its ovipositor through the stigma down the center of the style into the ovary, where it lays its egg. In a long styled flower the wasp is unable to reach the ovary and consequently deposits no egg therein. Hence wasps develop only in the ovaries of the short styled flowers, while the long styled flowers produce fig seeds.

As the tiny fig fruits, each containing a single hard seed, mature within the fleshy receptacle or fig the latter becomes soft and sweet and is greedily eaten by many birds, bats, and mammals. The germinating power of an uncrushed fig seed is not injured during its passage through the alimentary canal of bird or beast, and hence if dropped in a suitable place it may give rise to a new fig tree. Many species of *Ficus* start out in life as seedlings growing in the ground just as do the majority of forest trees, but there are also many species which prefer to begin their existence as seedlings perched upon the branches of other trees or upon old stumps. The seeds of these figs reach their elevated positions in the droppings of birds or bats which have fed upon the fruits. These perched seedlings send out long roots, which usually travel along the branches and trunk of the tree which supports them until they reach the ground. Having established connections with the soil the roots thicken up and usually fuse together laterally into a meshwork around their host, eventually encasing its trunk completely. Because of this habit of closely embracing the trunk and branches of the tree on which it has perched these figs are known as strangling figs, and in due time they actually strangle their host, but in order to do this they must replace it with a larger tree. Strangling figs may be considered objectionable in a commercial forest, for they sometimes replace a valuable timber tree with a tree of less commercial value, but in a rain-forest they are extremely valuable, for they always produce a larger tree than the one which they overcome.

It should be obvious that certain species of *Ficus* may be relied upon to accomplish much in the reforestation of our watersheds. They will not only spread spontaneously over the denuded areas, but they will become distributed through our decrepit forests and create therein a substantial element which will protect and strengthen the weaker trees which are unable to maintain themselves under existing conditions. Fig trees are notoriously hardy and thrive under abuse that would be fatal to the majority of trees. It is quite certain that live stock will never cause the death of the trees in a fig forest, and if we can induce these trees to become an important factor in our forest flora we need not fear that the temporary invasion of cattle will bring about such serious consequences as are sure to follow such an occurrence in our native forest. We do not mean to give the impression that fig trees alone may be relied upon to completely reforest our watersheds, but we do believe that they will become very

important self-distributing elements in all of our new rain-forests, even as figs now are in the rain-forests of most tropical and semi-tropical countries.

Economic Products From Fig Trees.

There is very little information to be found in literature regarding the timber and fuel value of the woods produced by the various species of *Ficus,* but such as we have found leads us to believe that as a rule these woods are soft, light and coarse-grained, and consequently of little economic value. The India rubber tree, *Ficus elastica,* yields a rubber of high quality. In the early days of the rubber industry this tree was planted on a large scale in Java for the production of rubber. As a forest tree it is one of the most desirable types which the genus *Ficus* affords. If planted extensively in our forests it might eventually become a source of revenue through the production of rubber, for the latex could be gathered without injuring the trees and it could be transported from sections from which timber could not possibly be removed.

Fig Trees Now Growing in Hawaii.

A survey of the flora of Honolulu for trees of the genus *Ficus* shows that there are twenty-two species already represented here by flowering specimens. To render these trees seed-bearing it is only necessary to introduce the fig wasps peculiar to each species. Among the twenty-two species the following can be employed to advantage in our forestry work: *F. Bengalensis, F. Benjamina, F. elastica, F. hispida, F. infectoria, F. macrophylla, F. religiosa, F. retusa, F. rubiginosa, F. Rumphii.* Attempts have already been made to introduce the wasps associated with five of the species named above, but thus far only those peculiar to the two Australian species, *F. macrophylla* and *F. rubiginosa,* have, for a certainty, become established in local trees.

The Moreton Bay Fig.

Among the several species of *Ficus* enumerated above *Ficus macrophylla,* the Moreton Bay fig of Australia, deserves special attention. It makes a splendid forest tree, attains very large dimensions, and adapts itself to a wide range of conditions. There are four fine specimens of this fig in Honolulu. One of these, which stands in Emma Square, is illustrated on the accompanying page. (Fig. 2.) Additional specimens have been located at Ewa on Oahu, at Puuomalei on Maui, and at Honomu on Hawaii. This tree is growing in California as far north as San Francisco, where it survives occasional light frosts. In Australia it is said to be very resistant to drouth, but delights in ample moisture. On the basis of this information we may reasonably conclude that this fig will thrive in Hawaii from sea-level up to an elevation of 6000 feet or more.

C. E. Pemberton, who has spent the greater part of the past year in Australia, has made a careful study of this tree, supplying us with much accurate data regarding its habits and those of the insects which are associated with it. He has consulted several eminent botanists in Australia, describing to them the uses which we plan to make of this tree, and they have enthusiastically recommended it for the very purpose which we expect it to accom-

Fig. 2. *Ficus macrophylla.* A large Moreton Bay fig standing in Emma Square in Honolulu. This tree has a spread of fully 100 feet.

plish here in Hawaii. Mr. Pemberton has sent the living fig wasps which are associated with the Moreton Bay fig to Honolulu and they have become established here, causing our local trees to produce viable seed for the first time. Mr. Pemberton also obtained and forwarded to us large quantities of seed, from which we have reared over 100,000 seedlings. These seedlings are now being planted out in groves on our watersheds in many parts of these Islands. When in a few years the resulting trees have reached the fruiting stage we shall only have to distribute the insects to our many groves, and each grove will at once become a source from which seeds will be spread by birds to the remotest parts of our watersheds.

Fig. 3. *Ficus macrophylla.* A large forest grown specimen exposed by the cutting down of the surrounding trees. For dimensions see text.

A properly matured fruit of the Moreton Bay fig is an inch or more in diameter. It has a very attractive appearance and a pleasant flavor. When the tree in Emma Square produced its first heavy crop of fruit it was visited by many people of the neighborhood, who gathered the fruits as fast as they fell from the tree. One of these collectors informed us that the fruits made excellent pies and puddings.

It has been suggested that the Moreton Bay fig may become a nuisance in pasture lands, but Dr. Maiden, Government Botanist of New South Wales, recommends that it be planted on dairy farms. Concerning this tree he writes as follows:

It will grow amongst rocks where scarcely anything else will grow, and it will stand being blown upon by fierce winds and being hacked about and otherwise ill-used. I admit that it can be put in the wrong place; but a Moreton Bay fig with plenty of room, so that it can live its life, is one of the most beautiful of trees, while its foliage and fruit are nutritious to stock, and its umbrageous head affords a grateful shade. . . .

Bearing in mind the way in which these and other native figs flourish exceedingly in the poorest soil, that cattle devour the leaves and branchlets greedily, that they will submit to persistent hacking back to an extent which will kill most other trees, it seems a matter for consideration that these trees should always be planted for shade purposes on dairy farms, and they should even be planted as a reserve of fodder in stony, sterile places where no grass will grow.

Our illustration (Figure 3) is from a small photograph of a Moreton Bay fig taken by Mr. Pemberton, who supplies the following data regarding the subject:

Ficus macrophylla. Typical forest shape when growing naturally. The surrounding forest was removed a few years ago. Height over all 232 feet, trunk to first branch 100

Fig. 4. *Ficus rubiginosa.* A large specimen of the Port Jackson fig growing by the side of the old Tantalus road.

feet, circumference 7 feet above ground 57½ feet. Photo taken from point 300 feet distant from tree.

While *Ficus macrophylla* will no doubt spread naturally to some extent in the open country, it prefers to begin its life as a seedling perched upon some other tree, and consequently we may rely upon it to spread in our dead and dying native forests, reinforcing these with strong growing trees which will eventually attain very large dimensions.

THE PORT JACKSON FIG.

Another Australian fig which promises to become an important factor in our forests is *Ficus rubiginosa,* the so-called Port Jackson fig. Mr. Pemberton, who has made a very careful study of this tree in its native haunts, expresses the opinion that it will prove even more serviceable to us that the Moreton Bay fig. He finds that in Australia it thrives in the driest situations and young seedlings may be found establishing themselves on exposed rocky hillsides where other vegetation is unable to survive.

We know of only a single large specimen of the Port Jackson fig in Honolulu, and this occurs by the side of the old Tantalus Road among eucalyptus trees. There are also five young trees in the grounds of the Federal Experiment Station. Our attention was first called to the large tree on the slopes of Tantalus about two years ago by Mr. Lorrin Thurston, who desired to know its name and country of origin. Mr. Thurston stated that this tree had first attracted his attention by its conspicuous ability to resist drouth. He had noticed on more than one occasion when the neighboring eucalyptus trees were seriously suffering or actually dying because of drouth this tree seemed to be experiencing no inconvenience, but maintained its foliage in a thrifty, growing condition. Mr. Thurston recommended at that time that steps be taken to distribute this tree over the dry foothills of our mountains. It certainly promises to become an important component of our lower barrier forests and may also enter into plant formations at elevations up to five or six thousand feet in some sections of these Islands. This tree has the reputation of being one of the most hardy trees to be found in Australia. In addition to being very resistant to drouth, it will survive all sorts of physical abuse, as is evidenced by the record of the specimen illustrated in Figure 6.

During the early months of 1921 Mr. Pemberton gathered a very large amount of seed of the Port Jackson fig in Sydney and forwarded it to us in Honolulu. From this seed we have reared upwards of 150,000 seedlings, many of which have already been distributed for planting out on our watersheds. We still have a large number of these seedlings on hand in our nursery in Honolulu, and we most earnestly solicit the cooperation of everybody interested in the welfare of these Islands in getting these trees into the ground over as wide a range as possible in order that this species may become established and actively participate in the spontaneous reforestation of our denuded watersheds.

THE CEDAR FIG.

A third Australian fig which Mr. Pemberton recommends highly for use as a forest tree in Hawaii is the so-called "Cedar Fig," *Ficus Henneana.* Trees

Fig. 5. *Ficus rubiginosa.* A tree ten years old from seed growing at Childers, Queensland.

Fig. 6. *Ficus rubiginosa.* This stump was grubbed out of the ground and allowed to lie around for a week or more before being set out again. The photograph shows the growth which it had made within the first year after being placed in its present position.

of this species never grow to the large size attained by specimens of the Port Jackson and Moreton Bay figs. They are moderate sized trees of fine shape and appearance, and produce large fruits which are very palatable to humans as well as to birds and beasts. Mr. Pemberton has supplied us with quantities of seed of *Ficus Henneana*, from which we have reared a very large number of sturdy seedlings, only a few of which have as yet been distributed. They are available to anyone desiring to plant them out.

OTHER AUSTRALIAN FIG TREES.

There are over twenty species of *Ficus* growing as wild forest trees in Australia. While most of these are peculiar to Australia, a few species, such as *F. Benjamina*, *F. glomerata*, *F. hispida* and *F. retusa*, range throughout the Malay Archipelago, India and Southern China. The three species, *F. macrophylla*, *F. rubiginosa* and *F. Henneana*, which we have already introduced into Hawaii, are probably the best of the Australian figs for our purposes. We have obtained seeds of some of the others in small quantities, from which we have reared a few seedlings, sufficient to test out the varieties under our conditions here in Hawaii. If they prove to be trees of exceptional merit we can easily secure seed in quantity and spread the seedlings to the same extent that we are now attempting to spread the Moreton Bay and Port Jackson figs.

(To be concluded.)

Orientation of Cane Rows.

In connection with the orientation of cane rows, F. M. Anderson, Manager of Paauhau Sugar Plantation Company, has furnished us information from The Louisiana Planter, commented upon by the Australian Sugar Journal, and supplemented by certain observations which he has made at Paauhau.

FROM THE LOUISIANA PLANTER: ORIENTATION, ITS EFFECT UPON PLANT LIFE AND GROWTH.

Orientation has been a new point in the culture of plants and much experimented with wherever efforts have been made to secure the greatest amount of heat and of sunlight for the benefit of the growing crops. In sugar cane this has been quite a special matter, and yet in Louisiana the tortuosity of the Mississippi River and adjacent streams and the general drainage of the plantation country in the alluvial lands away from the higher front lands to the lower rear lands, have compelled in nearly every instance the adoption of row planting, so that the sugar cane rows may go from higher to lower levels in order to secure the best drainage practicable. This being an accepted fact, it has perhaps been forgotten that orientation still has all of its original advantages. The sun rising in the east at its lower levels, gradually ascending until at midday in the tropics it becomes vertical, and its progress on to the western horizon gives those fields that are orientated an advantage in exposure to the sun's light and the sun's heat that is not always availed of, nor even understood.

The opinion of good cultivators of sugar cane in those countries where sugar cane is planted in rows has always varied more or less as to the distance that the rows should be apart. Rows five feet apart are scarcely wide enough apart to permit two-horse or mule cultivation. Such cultivation as can be done in fields of that kind would generally have to be done with straddling implements, or with the use of but one mule. With two mules the cultivator axle must be sufficiently high to pass over the growing crop without injury. Many years ago five feet rows were abandoned and six feet rows were adopted as the common standard, with exceptional widths of seven and even of eight feet; the more widely apart the row the greater is the range of sunshine that can be utilized. Eight feet rows have been known to produce better results than six feet rows, but perhaps there were other conditions rendering the general result not fairly comparable.

As human labor grew scarcer and the sugar crops became less remunerative, every imaginable device for weed killing has been utilized to meet the economic exigencies. One of these would be to have the least available tillable ground between the rows and thus to induce the plant to shade the ground at an early date. Sugar cane in five feet rows would shade the ground far more quickly than sugar cane in six or seven feet rows, all other conditions being equal. As the wider rows are preferable, permitting two-horse culture between the rows, our leading sugar planters have been rather loth to discontinue that kind of work, experience having shown that with our fertile soil and luxuriant growth of weeds and grasses, it is almost impossible to keep the fields clean and clear of weeds

without the turning plow, whether used in the hands of the plowman as a single implement, or whether combined with others and mounted on wheels.

As to the orientation of the cane crop in Louisiana, the merits of the method and the desirability of securing what orientation can be had are present problems that have never yet been solved, but may be in the future.

On the other hand, we find that in Czecho-Slovakia, Dr. Greisenegger has been experimenting with the question as to which beets yield the best results, those planted north and south, or those planted east and west. The experiments have been watched with considerable interest and have occurred over considerable areas in endeavors to ascertain definite data, but the problem apparently is still unsettled. Where moisture would be at a minimum, and where other conditions remained about equal, it was ascertained that in rows running from east to west the beets were of the best sugar content and produced the largest number of beet leaves, and the opposite result was obtained where the rows were planted north and south, the reverse way. A compromise was made and rows were planted running from northeast to southwest, and this showed a less sugar content than the east and west method, but with a better output than the direct north and south planting.

From The Australian Sugar Journal: Direction of Cane Rows.

Probably the direction of cane rows in the field is determined, as a rule, by questions affecting the convenience of working the land and keeping the crop clean, and without any special regard for the compass bearings of the lines. That this latter has some points worthy of consideration may be gathered from investigations relating to other crops, and in view of the known effects of sun and prevailing winds. An article in a recent issue of The Louisiana Planter deals broadly with this subject. On the banks of the Mississippi it is found necessary to plant in such directions as to permit of the cane rows running from higher to lower levels, thus securing the best possible drainage. There is also the question of the sun's rays, it being a recognized fact that light and heat are of prime importance in the growth of sugar. It is admitted that the "orientation of the cane crop in Louisiana, the merits of the method, and the desirability of securing what orientation can be had, are present problems that have never yet been solved, but may be in the future." In this connection we presume that the word "Orientation" is designed to mean the arrangement of the cane rows in an east to west line.

It seems that in Czecho-Slovakia experiments in the growth of beets have been conducted with this question in view. According to the Planter, it appears that whenever moisture was at a minimum and where other conditions remained about equal, the beets in rows running from east to west were of the best sugar content and produced the largest number of leaves; and the opposite result was noted where the rows ran north and south. Rows arranged northeast and southwest gave a better output than the north and south rows, but inferior to that of rows planted east and west. The subject may be worthy of observation in our own cane fields of equal fertility, but differing in the direction of the rows, where this has occurred.

OBSERVATIONS AT PAAUHAU.

	Area	Tons Cane per Acre	Quality Ratio	Tons Sugar per Acre
Rows running north and south	26.5	80.8	9.39	8.60
Rows running east and west	28.2	82.4	10.27	8.01

This was obtained on unirrigated land that had previously grown Yellow Caledonia variety of cane, whilst the crop referred to was D 1135 variety. The part having rows running east and west would be considered as having somewhat better soil and not quite so exposed to winds and draughts as the part having rows running north and south.

The results of this crop should not be interpreted to mean that all of our fields of D 1135 variety produce such tonnage, but several of them this year with this variety have exceeded fifty tons under unirrigated conditions. The quality ratio results will be tabulated from the subsequent crops of ratoons.

First Season Tasseling a Possible Benefit.

By R. M. ALLEN.

It is customary on most of our plantations to try to avoid tasseling as much as possible. When we see a field of young cane in heavy tassel the first season, we look on it with regret and feel that we shall suffer a loss. Based on this assumption, it is a practice on practically all irrigated plantations to cut-back in June and July. This is done at considerable expense and a decided loss in cane growth. The belief is that both are justified by the benefits resulting from the absence of first season tassels.

The results of some tests recently made at Kilauea would, however, indicate that tasseling the first season, under some conditions, is a benefit rather than a loss. In December, 1920, a very thorough count was made of tassels in a field (No. 9) of Yellow Caledonia cane that had shown unusually heavy tasseling. From these counts, which were continued for several weeks, approximately 48 per cent of the cane in this field was found to have tasseled. In December, 1921, the cane was harvested and careful weights made of the tasseled and non-tasseled sticks. Juice samples were also made from each type of stick with the following results:

	No. Sticks	Total Weight in Lbs.	Average Weight per Stick	Purity	QR.	Av. Lbs. Sugar per Stick
Tasseled Sticks	255	1,557	6.10	81.7	8.82	0.69
Non-tasseled Sticks	181	1,022	5.65	81.8	8.64	0.65
Second Season Sticks (suckers)	26	127	4.88	81.1	9.21	0.53

These results indicate that the tasseled sticks produced more cane per stick and more sugar per stick than the non-tasseled sticks. The second-season shoots or suckers were treated separately, since they would hardly be comparable to either of the other types. If these were thrown in with the non-tasseled shoots the difference in favor of tasseling would be even greater. It was found that the tasseled shoots had two or more long la-las which had continued to grow and enabled these sticks to compare favorably with the non-tasseled sticks. The method of procedure in handling this test was as follows:

All the cane in a line was cut and separated into tasseled, non-tasseled, and sucker shoots. These were bundled and weighed by means of a hand balance. Care was taken in cutting not to break the la-las. This was repeated in various parts of the field until what was thought to be an average of the field was obtained. After weighing, sticks of each type were tied together and taken to the laboratory for juice sampling. This was done with a hand mill and, in order to eliminate errors, a number of individual samples were run for each type of stick. Further juice comparisons were made of the la-la, the butt of tasseled canes without the la-la, full-tasseled sticks including the la-la, as compared with non-tasseled and sucker shoots. A total of twenty-one samples was run for these comparisons. The results are as follows:

	Brix	Sucrose	Purity	Q. R.
La-la Only	19.16	15.41	80.4	9.02
Tasseled Stick with La-la removed	18.56	15.12	81.5	9.08
Full-tasseled Stick, including La-la	19.09	15.60	81.7	8.82
Non-tasseled Stick	19.48	15.92	81.8	8.64
Second Season Shoot	18.45	14.97	81.1	9.21

Basing our calculations on these results, a field having an average of two sticks per lineal foot, or 17,400 shoots per acre, all in tassel would produce 4.0 tons of cane and .35 ton sugar more than a similar field not having tasseled. Of course, with a heavier stand the difference would become greater. There would also be an additional gain due to the growth made before cutting back. These results are based on one test only and are therefore not necessarily conclusive; but they point to a very interesting possibility and will bear further investigation in an endeavor to throw more light on the much discussed practice of cutting back. One feature of the proposition must, however, be borne in mind, namely, that the large la-las are more easily broken by the wind than the non-tasseled sticks. This might be a drawback to large la-las in windy districts.

La-la sticks being heavier on the ends also recline more and are more likely to be rat-eaten than the non-tasseled shoots. The tests reported above were made in a rat-infested area; hence an even greater difference in favor of tasseling might be expected in districts not troubled with the pest.

Kilauea, Kauai, December, 1921.

Boiling House Recoveries by the Ash Sucrose Formula.

By RAYMOND ELLIOTT *and* J. C. CHAPMAN.

A system of ash-sucrose control was run over a six weeks' period, with the idea of comparing the recoveries so obtained with the calculated S. J. M. recoveries, and with the actual recoveries. The ash determinations were made according to the H. C. A. Methods of Chemical Control, 1916, the syrup and mixed juice being run daily, the other materials weekly. The sucrose figures used are those obtained in the routine laboratory control.

The ash and sucrose values, as determined, follow:

		Syrup	No. 1 Sugar	Waste Molasses	Mixed Juice	Press Cake	M. J. Cor. for Lime and Press C.
Week ending 7/23/21	Ash	1.87	.59	9.49	.....	....	.....
	Sucrose..	53.24	96.96	30.51	.....	....	.....
	Ratio ...	.0351	.0061	.3110	.....	....	.....
Week ending 7/30/21	Ash	2.00	.66	9.71	.....	....	.....
	Sucrose..	53.38	96.96	30.64	.....	....	.....
	Ratio ...	.0375	.0068	.3169	.....	....	.....
Week ending 8/6/21	Ash	1.85	.67	10.19	.417	5.54	.420
	Sucrose..	49.64	97.01	30.65	10.57	1.38	10.54
	Ratio ...	.0373	.0069	.3325	.0395	....	.0398
Week ending 8/13/21	Ash	1.83	.58	10.41	.394	4.70	.414
	Sucrose..	51.8	96.9	30.57	10.73	1.46	10.69
	Ratio ...	.0353	.0060	.3405	.0367	....	.0381
Week ending 8/20/21	Ash	1.58	.51	9.94	.347	3.96	.369
	Sucrose..	51.01	97.08	30.66	10.60	1.55	10.56
	Ratio ...	.0310	.0052	.3242	.0328	....	.0349
Week ending 8/27/21	Ash	1.70	.69	9.53	.352	3.35	.365
	Sucrose..	51.53	97.01	30.70	10.50	1.78	10.45
	Ratio ...	.0330	.0071	.3104	.0335	....	.0349
True Average	Ash	1.81	.62	9.89	.378	4.36	.393
	Sucrose..	51.81	96.99	30.63	10.60	1.55	10.56
	Ratio ...	.0349	.0064	.3229	.0357	....	.0372

From the figures tabulated above the recoveries were calculated according to the method advanced by S. S. Peck in Vol. VII, Planters' Record. His formula follows:

$$\text{Recovery} = \frac{\text{Ash Sucrose ratio of molasses} - \text{Ash sucrose ratio of Juice}}{\text{Ash Sucrose ratio of molasses} - \text{Ash sucrose ratio of Sugar}}$$

This formula was applied upon the syrup rather than upon the clarified juice. Although the syrup in the Paauhau Mill contains the remelted low-grade

sugars, which are returned to process at the liming tank, the recoveries should be strictly comparable with the S. J. M. recoveries, which are likewise based upon the syrup.

In an effort to eliminate this possible source of error, the recovery was based upon the raw juice also after the second week. Since mineral matter is added to the mixed juice in the form of lime, and since a large quantity is removed in the press cake, this necessitated a correction for the sulfated ash value of the lime, and a determination of the ash in the press cake. The results are, perhaps, open to question, due to the fact that the press cake is not weighed, and due to the varying ash equivalent of the lime. The recoveries obtained, however, are consistent, and are closer to the actual recovery than are either the S. J. M. or the ash sucrose recoveries based upon the syrup.

The calculated recoveries follow:

Week Ending	Ash Sucrose Recovery on Syrup	S. J. M. Recovery	Ash Sucrose Recovery on Mixed Juice
7/23/21	90.49	91.08	.....
7/30/21	90.10	91.02	.....
8/ 6/21	90.66	90.76	89.90
8/13/21	91.24	90.86	90.40
8/20/21	91.95	91.93	90.69
8/27/21	91.53	91.66	90.83
True Average ..	91.00	91.28	90.27

The actual recovery in the boiling house for the six weeks, as shown on the balance sheet, was 89.91.

Another set of ash determinations was run, during the same period, to ascertain the percentages of sucrose from the different massecuites going into the sugars and molasses The same formula was used, substituting the value of the "ash sucrose ratio" of the massecuite in question for that of the juice. That is the per cent of sucrose recovered in the sugar on that in the massecuite is equal to:

$$\frac{\text{Ash Sucrose ratio of molasses} - \text{Ash Sucrose ratio of Massecuite}}{\text{Ash Sucrose ratio of molasses} - \text{Ash Sucrose ratio of Sugar}}$$

This was found to give very good results with first massecuite, but with the second and third massecuites the difficulty in obtaining representative samples of second and third sugars made this determination unfeasible.

The results obtained in this experiment would indicate that the theoretical yield, as calculated by the ash sucrose formula, checked very well with that calculated by the S. J. M. formula, especially when based upon the syrup. The use of mixed juice in this connection entails two extra ash determinations and a rather involved calculation. There could be no advantage in using the mixed juice in a mill where the remelt is not returned to process ahead of the evaporators. Syrup would be the logical material to use in such a case.

Paauhau Sugar Plantation Co.

Buffer Action of Phosphoric Acid in Hawaiian Soils.

By W. T. McGeorge.

The early conception of soil acidity or sourness involved a simple absence of sufficient base to neutralize the acidity developed during organic decomposition or that caused by lack of aeration.

More recent investigations, resulting from improved analytical methods, associate iron, aluminum, and manganese with the toxicity of acid soils, a deficiency of lime or magnesia tending to promote the solubility of the above in the soil solution. The salts of these metals, being weaker bases, are more highly hydrolyzed, increasing thereby the H ion concentration or acidity of the soil solution. In lime, then, we have an agent functioning in part as a "guard" against the introduction of toxic amounts of the salts of these metals and the accompanying acidity. Conditions conducive toward such action of lime involve, however, proper aeration as a source of carbon dioxide, this being essential to the soluble calcium bicarbonate.

In the absence of lime, we have other agents functioning in a similar manner but to a lesser degree. Among these may be included the phosphates, such action being generally referred to as a "buffer" action. That is to say, the H ion concentration suffers considerable reduction in the presence of soluble phosphate or soluble salts of other weak acids, such as acetic and carbonic, which are only slightly dissociated. While the extent to which phosphates function as such in our soils is yet an undetermined factor, the possibility is not beyond reason.

Our studies on island soils have indicated the predominance of aluminum phosphate as compared with those of iron and calcium in the order given. Does this add further indication of phosphates functioning as neutralizers for the excess of soluble iron and aluminum salts? We have data showing the presence of an excess of lime to be accompanied usually by high available phosphate; for example, the Kau section of Hawaii and the Puuloa and Ewa districts on Oahu. Theoretically in such cases we would anticipate just such conditions to exist, namely, lower acidity, less hydrolyzable salts of aluminum, iron and manganese, and high available phosphoric acid. Furthermore our data indicate low lime content and its accompanying higher acidity is associated with low available phosphoric acid and theoretically the environment conducive toward the presence of the hydrolyzable salts noted above. In such cases it is not unreasonable to assume phosphoric acid functioning as a buffer, as numerous instances have been noted in our soils of similar total phosphoric acid content but widely varying available phosphoric acid.

The availability of phosphoric acid in virgin Hawaiian soils is notably increased by cultivation (aeration), fertilization, and other tillage practices. It is possible to explain this on the basis of a stimulation of the buffer action of calcium bicarbonate on the introduction of carbon dioxide into the soil atmosphere, through aeration. Thus are thrown out of solution the elements standing higher in the electromotive series whose phosphates (hydrated) are less soluble and less easily attacked by the agents of solution. Response to phosphate fertilization on the virgin soils of the Islands has been noted in numerous cases.

A summary of forty-seven phosphate experiments harvested by the Station agriculturists showed only fourteen instances in which a response was obtained. These were principally on the mauka lands of Oahu and Kauai. The mauka lands are almost invariably low in lime as compared with the makai, and usually more acid.

It has been noted further that the subsoil is markedly and almost uniformly lower in available phosphoric acid than the corresponding top soil. Here again we have a lower lime content and as shown by its solubility less present as carbonate. There is also less aeration, higher acidity, and other factors conducive toward the conversion of the hydrates of aluminum and iron into their soluble salts. From the foregoing it is probable that in our subsoils and virgin top soils, deficient in lime, phosphoric acid functions in part as a neutralizer for soluble iron and aluminum salts. There results from the above processes an excess of the insoluble phosphates (hydrated) of iron and aluminum as shown by our soil analyses. It is further evident that the more consistent response to phosphoric acid on the virgin soils may be due in part to a reaction with the iron and aluminum salts. This is further indicated in the general observation of an increase in available phosphoric acid with cultivation on the Island types.

Notes on Some Enemies of the Nut Grass in the Philippines.

By Francis X. Williams.

The nut grass, *Cyperus rotundus* L., is one of the best known and most obnoxious of tropical sedges. It is certainly a very familiar species in the Australian, Hawaiian and Philippine cane fields.

The name nut grass is probably used because the root-like stems springing from the solid bulbous base of the sedge normally bear hard ovoid tubers, each capable of producing another plant. It is this habit of reproduction, well below the surface of the ground, that makes the eradication of nut grass so difficult, for, whereas a thorough cultivation of the soil will rid it for some time to come of various weeds and grasses, *Cyperus rotundus* will be about the first to spring up and thrust out its handsome but unwelcome leaves.

While this sedge has its enemies, I found that on the whole it was but little affected by them. The time devoted to the nut-grass problem, however, was short and so the observations are of an incomplete nature.

One or more species of fungus, one mealy bug, one weevil, and two or three species of moth larvae were observed attacking the plant.

The fungus is a species of rust, determined by O. A. Reinking as *Puccinea* sp., and characterized in its later stages, on the upper side of the leaf, by roundish or oblong, pale yellow spots with a brown center. Below, the brown spots are oblong pustules which, before they burst, suggest an armored scale-insect of some sort. In time these spots become more extensive, and the tip of the leaf

is the first to brown up and wither. This fungus is conspicuous among nut grass, but does not appear to be very effective. In addition, a yellowing of the leaves, with or without spots, is common in this sedge.

The mealy bug is rather a small species that works at or near the base of the leaf-sheaths and even on the bulbous portion below ground. Locally it may be quite abundant. During November, 1920, when the heavy rains had already fallen, I found what appeared to be this species occurring rather sparsely underground on the bulb. The next search for the mealy bug was in June and July, 1921, or at the commencement of the rains. Then no specimens were found on the bulb, but all were at the base of the plant between leaf bases. Many of the insects were young. A brief search among grasses mixed in with the *Cyperus* brought to light at the base of the stems of Cogon, *Imperata cylindrica*, var. *koenigii*, a very similar mealy bug.

I have found no coccid of the genus *Antonina*, such as was observed in Australia by F. Muir, attacking nut grass.

The weevil appears to be a little more plentiful than the moth borers, though none are abundant. It is quite a small insect, whose footless grubs work into the bulb from above and kill the plant. The effect is shown in the central leaves, which die early and shrivel up; thus attacked plants can easily be detected. The grub pupates in the bulb. My observations on this insect were made in November and December.

The tortricid moths—there appear to be two species—each have about the same habits, and, like the weevil, were not found to be conspicuous in nut-grass areas. I do not think I have seen more than a five per cent killing of this sedge from the combined attacks of beetle and moths. The symptoms of the affected plants are very much like those affected by the weevil. If such a plant be examined, its central axis will be found hollowed to the bulb and commencing wet decay. An old attack shows externally a withering and finally the collapse of the whole plant.

The moths are of an inconspicuous brown and gray, and much smaller than the sugar cane leafroller, *Omiodes accepta* of Hawaii. I reared a few of them from larvae, but none from egg to adult. What I take to be the eggs of one of these species are deposited in a line on a *Cyperus* leaf, and slightly overlap or shingle. They are flat discs, short oblong, and less than a millimeter in length. On hatching, the young larva immediately embeds itself in the tissue of the leaf, working downwards, and eventually tunnels the axis of plant as far as the bulb, which it may even hollow out completely. Its frass is extruded in a heap against the base of the sedge. When ready to transform into a pupa, an escape aperture for the latter is bitten through the appressed leaves above, and a silken tube or cocoon spun in the stem. The pupa is about six millimeters long and is provided with proper head and abdominal armature to help work its way out of the cocoon and partly to extrude itself through the stem. There it splits and the moth is disclosed.

A small braconid wasp, resembling an *Apanteles*, attacks the caterpillar and spins a cocoon nearby.

A single diminutive tineid moth was reared in a jar containing a lot of nut grass. Its early stages were not observed.

The introduction of plant-feeding insects to destroy certain troublesome weeds or shrubs needs a very careful study. This, then, is very true of nut-grass insects. It has not been determined whether any of these would turn their attention to forage grasses, etc., and thus become pests. I can only say that at present the subject has not been studied sufficiently to cause a decision to be made in favor of or against introducing these nut-grass enemies into Hawaii.

Varieties at Honokaa.

HONOKAA SUGAR CO. EXPERIMENT NO. 7, 1921 CROP.

This experiment is in field 18 at an elevation of 1000 feet. The cane is first ratoons, long, and was 25 months old when harvested in June this year.

The plant crop was harvested in May, 1919. From May to September, 1919, this field received no attention. A fairly thick layer of trash covered the entire experiment. This trash was not pali-palied as it was the intention to test the ability of the different varieties to come through this layer of material. The D 1135 came through the trash to an excellent stand, the Badila also came through to a good stand. The H 109 and the Caledonia were not able to come through to any extent, and the stand of these two varieties was very poor. No replanting was done.

Young second ratoons from Honokaa Experiment 7. The D 1135 is on the left and the Yellow Caledonia on the right. A close study of this photograph will show the D 1135 to have a much better stand and to be much more vigorous than the Caledonia. There has been no trouble about weed control in the D 1135, while the weeds are bad in the Caledonia.

The yields obtained for the two crops harvested are tabulated below:

Variety	Yields per Acre			
	1919 Crop		1921 Crop	
	Cane	Sugar	Cane	Sugar
D 1135	54.1	6.6	33.2	3.41
H 109	45.0	5.3	21.6	2.72
Yellow Caledonia	34.5	4.4	16.1	2.05
D 1135	55.0	6.7	36.9	3.75
Badila	38.4	4.6	27.9	3.44

In this experiment in both crops the D 1135 has been distinctly better than any of the other varieties tried.

This experiment will be carried through another crop, using the same methods.

Details of Experiment.

Object:

To compare Yellow Caledonia, H 109, D 1135 and Badila under conditions prevailing in the unirrigated sections of Hamakua.

Location:

Honokaa Sugar Co., field 18, beginning 2 lines below the Government road, and on the Honokaa side of the field road.

Crop:

First Ratoons—Yellow Caledonia, H 109, D 1135 and Badila.

Layout:

Thirty-three plots, each 1/10 acre, consisting of 6 lines, each 4½ feet wide and 161 1/3 feet long.

Plan:

10 plots Yellow Caledonia (1, 4, 7, 10, 13, 16, 19, 22, 25, 28).
12 plots D 1135 (2, 5, 8, 11, 14, 17, 20, 23, 26, 29, 30, 32).
9 plots H 109 (3, 6, 9, 12, 15, 18, 21, 24, 27).
2 plots Badila (31, 33).
Fertilization—Uniform by plantation.

Experiment planned and laid out in 1917 by W. P. Alexander.

J. A. V.

Has Uba Cane Commercial Possibilities in Hawaii?

By H. P. Agee.

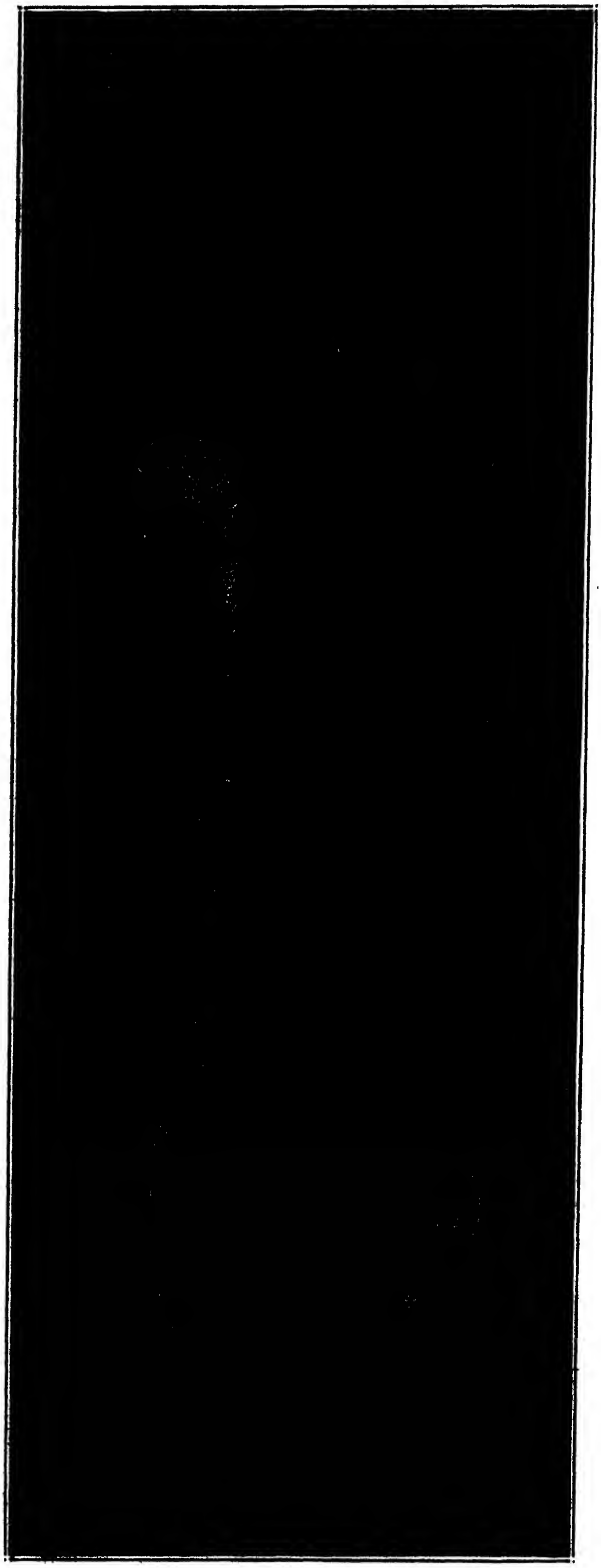
Recently we have had the opportunity of discussing Uba cane with B. E. D. Pearce of Natal. This variety is the commercial cane of Natal and is grown almost to the exclusion of all other varieties.

We showed Mr. Pearce an area of this cane which is growing at the U. S. Experiment Station, from which a considerable amount has been distributed throughout the Islands. We were interested in learning from him whether the cane which we have is actually the Uba cane of Natal. There has been and there still remains doubt as to this. The plot of cane had been ratooned several times without much fertilization or irrigation. The majority of the sticks were very thin. The range of the size of stalks found is shown in the accompanying photograph. This picture was made from cane growing at Makiki. Most of the stalks are of the smaller size. Mr. Pearce thinks that the Uba cane of Natal is very similar botanically to the one in Honolulu. The closely adhering leaf sheaths, the large quantity of flaky wax on the stalks, and the general character of the cane, all conform. Probably they have the same cane, but a better strain of it in Natal, as he believes the greater part of their cane corresponds more nearly to the larger cane in the photograph.

Uba cane is grown in Natal, we learn, because it is the only variety which is capable of producing good ratoon crops for ten or twelve years under severe drought conditions. It is also a cane that is liked there on account of its resistance to light frosts. Mr. Pearce has seen it survive within seven miles of a snowfall at the same elevation. The rainfall in Natal amounts to about thirty-five inches a year, the greater part of which falls between November and March. Severe droughts invariably occur during the summer months. Sometimes these are so serious that much of the crop is lost, even though the variety is a drought resisting one.

The agriculture of Natal, we understand, is very simple. The cane is planted in shallow furrows about four and one-half feet apart. The dry adhering leaves are not removed and the stalks are dropped as one or two running lines without being cut into short seed pieces. In general there is no fertilization and no irrigation. The fields are not replanted more than once in ten or twelve years and often longer.

In Natal, Uba cane yields better as first, second, or third ratoons than it does as plant cane. A crop of cane occupies ground for two years. Thirty or forty tons of cane is a common yield. Mr. Pearce says that one field on his plantation gave forty tons of cane per acre as eighth ratoons. Two or three cultivations suffice in ratoons. Hilling is not resorted to. Nine or ten tons of cane produce a ton of sugar, under mill work that is not the best. Uba cane planted in favorable situations, such as river bottoms, often yields sixty to eighty tons of cane. The disadvantages presented by the thin character of the sticks are offset by its other advantages. We are told that one laborer is expected to cut and load on portable track cars about one and one-third tons of cane as a day's work. That is, three men cut and load four tons. A laborer there received less than half the wages now prevailing here.



The cane grown under the name of Uba in Hawaii, showing the range in the size of stick.

In Hawaii, though we contend with drought to a considerable extent, and though the shortage of irrigation water in certain localities is a limiting factor bearing upon cane areas, this cane, with its record for long standing usefulness in Natal and Portuguese East Africa, has never been given a commercial trial here. Such a test is, however, now under way in Hamakua, where the Honokaa Sugar Company has planted several acres of the cane we have here under the name of Uba. This test will be followed with interest.

We learn from Dr. Mario Calvino that Uba cane is now attracting some attention in Cuba. In Porto Rico it has made appeal on account of its immunity to the Yellow Stripe disease. Dr. Calvino finds it an early maturing cane, "interesting to Cuba notwithstanding that it presents the serious disadvantage of being a little thin and has too much straw."

A recent article by Dr. Calvino quotes a report from Jamaica which reads to the effect that this cane was imported from Zululand to Jamaica in 1916 and has shown itself to be so promising that about 15,000 cuttings were distributed lately. They found the cane much better than they had anticipated. A footnote to Dr. Calvino's article states that recent news came from Jamaica that the cut-

tings of the Uba cane of Natal had been extended a good deal and that the variety is increasing in favor from year to year, giving less fiber and greater purity. Data are presented showing that the cane at the age of six and one-half months yields 33.2 tons per acre, there being twenty-six canes to the plant.

The following juice analyses taken from the Jamaica report are of interest:

Age of Cane in Months	Juice				
	Brix	Sucrose	Purity	Glucose	Glucose Ratio
6½	16.40	13.09	79.80	0.84	6.42
8½	15.70	12.97	82.62	0.38	2.93
9½	17.70	14.46	81.70	0.39	2.70
10½	19.90	16.84	84.62	0.39	1.84
11½	19.80	17.24	87.99	0.191	1.09

Dr. Calvino, attracted by the early maturing quality of this cane, had analyses made on his own behalf from cane grown in Cuba. From his data we take the following:*

Age of Cane		Juice			
Months	Days	Brix	Sucrose	Purity	Glucose and Salt
9	21	20.40	16.10	78.86	4.30
10	28	17.85	15.50	86.85	2.35
11	9	20.00	17.70	88.50	2.30
12	13	17.50	12.00	68.57	5.50

The Cuba station has sought a method of crossing Uba cane with varieties of better physical characteristics. At first two seedlings were obtained, crosses of the Uba cane of Natal and D 74, and in 1921 another was secured.

The Uba cane of Natal, according to Dr. Eva Mameli of the Cuba station, can function as a female in crossing. Its pollen is sterile. Recent microscopic investigations by Y. Kutsunai of cane flowers at the H. S. P. A. Experiment Station indicate the same is true of the cane we have here under the name of Uba.

We are now attempting to cross H 109 with Uba, and in this the U. S. Experiment Station has extended to us the use of the Uba growing there, their area of this cane being considerably larger than ours. As previously stated, there is question as to whether or not the cane which we have under the name of Uba is the same as the Uba of Natal.

Dr. Calvino, in his article entitled "The Uba Cane of Natal," states that as a forage crop it is better than the Japanese or Zwinga cane and is often cul-

* The poor quality of the cane after 12 months, 13 days, was said to be due to heavy rains.

tivated for this purpose. He gives tables comparing the Uba cane of Natal with "Japanese" cane. These data are not sufficiently descriptive to enable us to identify our cane either as his "Uba" or "Japanese."

Noel Deerr, in his new edition of "Cane Sugar," has the following to say under the heading "The Uba Cane":

This cane is of peculiar interest and history. It first appears in the more recent history of the cane as one of a number imported to Mauritius from Brazil in 1869, and it is mentioned as a well-established variety in Brazil in a report appearing in the Sugar Cane for June, July, and August, 1879.

In 1882 and 1883 Messrs. Daniel de Pass & Co., of Reunion, Natal, imported canes from both Mauritius and India. Among these was one bag with a damaged label on which was to be read the letters "Uba," and these letters were taken to be but a part of the name of the cane, and hence arose a legend that the Uba cane represented another with a longer name containing these letters, whereas actually the correct name had been deciphered from the damaged label.

More lately Barber has recognized this cane as one of the Pansahi group indigenous to Northern India; and its presence in Brazil, evidently from early times, is unexplained. The most reasonable supposition is that it was brought by the Portuguese from India, and not as the writer once suggested that it is the original Creole cane which travelled from India via the Mediterranean to the West Indies.

The origin of the word Uba is to be found in Piso's description of Brazil (1658), where Viba (and elsewhere Vuba) is given as the native Brazilian term for a reed, and was used at that time as a synonym of the sugar cane. To this cane is also attached the terms of "Japanese Cane," "Kavengire" (evidently a corruption and misapplication of Cavengeric), and in Argentina "Bamboo de Tabandi" and "Sin Nombre 54."

This cane is very different from other cultivated varieties. It is only about half an inch in diameter, with internodes up to six inches long. It is of a green color, with a very heavy coating of wax, giving it a bluish bloom, and it contains an exceptional quantity of fiber, reaching up to 17 per cent. The juice afforded by it is of reasonable density and purity.

The Zwinga cane, also in some cases called Japanese Cane, is similar, with the exception of a swollen node, that of the Uba being equidiametrical with the internode. The application of the term "Japanese" merely implies that at some time these canes travelled from India to Japan, and thence to other parts of the world.

Plate X (page 80) shows the cane, as drawn from a specimen obtained in Porto Rico, with ascertained pedigree from Brazil, via Argentina.

The color plate in Noel Deerr's work is not representative of the Uba cane as grown in Natal, according to Mr. Pearce.

In The Australian Sugar Journal of January 6, 1922, we learn from a brief article headed "Uba Cane in Bundaberg District" that this cane is now grown on a commercial scale in the Fairymead Plantations. A correspondent, Horace Young, replying to an inquiry from that Journal, said:

We are greatly pleased with this variety for black or alluvial soils. The cost of cultivation, weeding, scarifying, etc., is less than half that of any other variety we know, and though the C. C. S. is lower than some others,—averaging between 12 and 13,—still the crop is much more even, and far heavier per acre. We are fully satisfied with it for the above soils, and intend continuing to plant it largely, having no fear of its being a "greedy feeder." The fact is it is a deep rooter and draws from the subsoil, and we find it yields more sugar per acre than other varieties on these soils. We do not recommend it for red or volcanic soils. It also certainly stands frost better than most varieties cultivated.

The Australian Journal concluded its article by saying although the Uba cane has been largely grown in South Africa, it has nòt been regarded with favor in Queensland.

Hawaii should take steps to ascertain definitely whether the commercial cane of Natal is a better strain or variety of cane than the one which we have here under the name of "Uba." If it is, its introduction should be considered, subject to such safeguards as the entomologists and plant pathologists of this Station and the Territorial Board of Agriculture and Forestry may prescribe.

Liming Cane Juices and Its Effect on Undetermined Losses

By H. F. HADFIELD.*

Before entering upon the details of this paper it would be as well to hear what the general opinion is upon the effect of liming cane juices. It is generally known that raw cane juice requires the addition of some clarifying agent to precipitate the impurities before cane sugar can be satisfactorily made from it. Lime is regarded as being the best, and so far the only agent for this performance, and when mixed with cane juice and heated at about the boiling point, clarifies it in such a way that, after settling in tanks, the clear juice can be drawn off, leaving the scums at the bottoms to be further treated. Out of some six hundred clarifying agents put on the market, lime seems to be the only agent so far that reliably clarifies the juice.

It is claimed, however, by authorities that if cane juice is over-limed at high temperatures the results are detrimental to the manufacture of cane sugar; and for this reason, if some other clarifying agent could be invented to take its place without injurious effects, there is no doubt that it would be dispensed with.

Lime is therefore added solely for the purpose of clarification, and to do this right and not reap any of the injurious effects, it is claimed that it should be added to the juice until neutral, for if added until alkaline, firstly it acts on the reducing sugars, forming lime salts of organic acids which are dark colored and easily decompose, forming acid substances, causing a loss in sugar and consequently a reduction in the per cent recovered; and secondly, these lime salts retard evaporation and crystallization, and so cause a reduction in percentage recovery. All raw sugar manufacturers know this and are ever watchful.

In our factory, during the first part of the season, the undetermined losses were so great that it was evident that something unseen was happening, the cause of which had to be remedied. It was at first very puzzling to know just where these losses occurred, when positively all mechanical losses, such as entrainment, faulty scales, leaks, etc., had been checked up. One wonders if, after all, there is not a good deal of truth in the fact that the dextro-rotating gums due to high extraction were not responsible for an excess reading of sucrose in the polariscope, thus increasing the estimated sugar and consequently the

* Read at the Nineteenth Annual Meeting of the Hawaiian Chemists' Association, November 14, 1921.

undetermined losses. Offering this solution as an easy way out of a complex difficulty, and though there may be a good deal of truth in this statement, it is doubtful whether the excess reading is so great as to offer it as a conclusive cause for large undetermined losses.

In order to find the extent of these losses, it is usual to make a balance of recovery and losses, but as this entailed a good deal of work, a simpler and equally good method was adopted. As the undetermined losses governed the boiling house recovery, the following formula was used:

$$100 \times \frac{\text{Tons Polarization in Sugar bagged}}{\text{Tons Polarization in Mixed Juice}}$$

This approximate Boiling House Recovery, in conjunction with the amount of low grade massecuite and syrup on hand, in which the sugar can be easily estimated each week, furnished a very quick means of control.

It is logical to suppose that if large losses are occurring which are not mechanical, inversion caused by deterioration of juice may be their causes. It was therefore determined to correct any acidity in the juices by adding extra lime at the scales, the presses, and at the re-settling tanks. It was essential, however, beforehand to find some method of improving the drying qualities of the low-grades, in order to overcome any viscosity or foaming of massecuites which might occur during over-liming.

An iron flume-shaped mixer was made with rounded bottom, opened at one end, 18 feet long, 24 inches wide, and 18 inches deep, inside of which ran a 2 inch square shaft, having fastened to it and staggered 14 blades 7½ inches long and 2 inches wide. The whole was driven by means of a sprocket wheel and chain at a speed of 12 R. P. M., and attached to the counter-shaft from the low-grade machines. This replaced the unreliable Scroll-mixer over the low-grade machines, and prepared the massecuite by mixing it with a hot stream of final molasses at 60° C., thoroughly breaking its viscosity and diluting it down to about 93 Brix. This method proved very successful, and increased the drying considerably, not affecting in the least the gravity purity of the molasses.

Having successfully put in operation a machine which would overcome any difficulty that might arise through over-liming, and also gained a quick figure for control purposes, preparations were made to conduct and watch the results of over-liming without fear of jeopardizing the speed of drying. As it was intended to run the whole factory as alkaline as possible in order to suppress any inversion, pipes were laid from the main lime pipe line to the presses and re-settling tanks.

The juice and mud at these different stations were always kept alkaline. Also the sweet-water from the presses, and as this was used as maceration on the mills, it formed the basis of an experiment described later on liming of mills. Additional amounts of lime over and above the usual necessary for clarification were added to the juice till it became dark in color and decidedly alkaline; soda-ash added to the seed till alkaline, to the low-grade massecuite during boiling, and with the final molasses being mixed with low-grade massecuite as a dilutant. Thus it was endeavored to keep all juices, syrups, and massecuites

alkaline, though in the last case we were never able to drop an alkaline low-grade massecuite.

The results obtained by running an alkaline juice were very marked. The total recovery increased 5%, the undetermined losses decreased from 4.0 to 0.7, showing that something important had been accomplished. Over-liming caused no caking of sugar in storage, no extra scale in evaporators; there was no need of adding phosphoric acid as there did not seem to be any harm done. The viscosity of the low-grade massecuite remained unchanged, no foaming of massecuite in cooling tanks.

In fact the only drawback seemed to be that the pans boiled a little slower than usual, though by so doing a harder grain was made, an important factor where low-grades are subjected to water or thin final molasses for diluting purposes before drying.

With alkaline juices the advent of *Leuconostoc* was to be expected, and the pipes and tanks between the scales and heaters were filled with it; sometimes ten or twelve sugar bags full would be washed out. There seemed no cause for alarm, however, as the heater pump kept going in spite of it. The pump, in fact, had a tendency to break it up, for upon examining the mud cake small pieces of *Leuconostoc* were to be found well distributed and intermingled with the mud.

The total lime was increased from 1.06 lbs. to 1.89 lbs. per ton of cane, and contrary to what has been already stated with regard to over-liming, the recovery of sugar increased. Lime has therefore not been used solely as a clarifying agent, but for an entirely different purpose, that of actually increasing the output of sugar by stopping decomposition of juice during its further process of manufacture, and after clarification had been accomplished.

The following table shows the progress made during each period by the addition of lime:

	1st Period	2nd Period	3rd Period	4th Period	5th Period
Juice Limed to Litmus	Neutrality	Alkalinity	Alkalinity	Alkalinity	Alkalinity
Pounds Lime per Ton Cane	1.06	1.34	1.45	1.54	1.89
Total Recovery	87.67	91.846	92.158	91.235	92.6
Boiling-house Recovery	89.09	93.3	93.5	92.66	94.07
Undetermined Losses	4.19	0.718	0.758	1.064	0.7
First Mill Juice Purity	87.4	88.4	87.6	86.45	87.0
Mixed Juice Purity	85.44	86.0	85.73	85.34	85.35
Clarified Juice Purity	86.0	86.3	87.4	86.66	86.5
Syrup Purity	87.0	88.0	87.9	86.54	86.9
Gravity Purity Final Molasses	35.42	36.6	36.9	37.1	38.12
Apparent Purity Final Molasses	30.0	34.0	34.0	34.0	34.0
% Ash in Sugar	0.41	0.55	0.59	0.52	0.63
% Ash in Final Molasses	8.04	8.62	8.3	8.39	9.05
Low-grade Mc. per Ton Cane	0.84	0.84	0.79	0.89	0.93
% Pol. in Cane	12.59	12.78	12.9	13.0	12.92
Stoppages in hours	23.55	54.50	25.0	82.45	74.25

The table shows plainly that by the increase of lime there was an increase in recovery, a decrease in undetermined losses, an increase in gravity purity of final molasses, with a corresponding increase in apparent purity, an increase in the ash both in sugar and in final molasses. It also shows that the decrease in recovery during the 4th period may be due to the fact that the stoppages increased to 82 hours, and in spite of an alkaline juice, losses due to inversion were going on.

It is astonishing how quickly juice will deteriorate, and if left undisturbed bubbles may be seen rising to the surface, showing that the bottom begins fermenting first. A case in point is where a continuous flow of hot juice is allowed to run over from one tank to another during the whole week. If the bottoms are not agitated large losses may result. It is important, therefore, that all such tanks either be emptied and washed every twenty-four hours, or eliminated altogether.

Liming at the Mills: Where compound maceration is practiced and intermediate carriers are continually transporting bagasse from mill to mill, and cush-cush carriers cleaning juice screens, one cannot help being impressed with the acrid smell due to acidity. Where this is occurring it is usual to suppose that decomposition is going on. It was with the idea of correcting this acidity, and hence any loss which might be occurring, that lime was added on to the mills as an experiment. Considering that an alkaline sweet-water was already added as maceration it was thought that an additional amount of lime might sweeten the last mill juices to such an extent that, in being pumped back over to the other mills, the whole system would become alkaline. It proved a failure, however, on account of most of the lime being carried over with the bagasse to the furnaces, slippage of last mill, and to the fact that twice as much was being used as usual, and even though the fields eventually recovered it, the process was not looked upon as successful.

After two weeks' experiments, a better method was evolved. Bearing in mind a twelve-roller mill and a compound system of maceration in vogue, a tank was erected at an elevation, into which milk of lime of under forty Brix density was pumped. From this tank a thin stream of lime was allowed to run by gravitation into the third mill juice receiving tank until the juice became alkaline. From here in the course of maceration it was pumped into the bagasse as it emerges from the first mill, giving it that characteristic yellow color. This strongly alkaline bagasse undergoes pressure at the second mill, its alkaline juice joining the unlimed first mill juice at the mixed juice tank, from which it is pumped to the scales in the boiling house. The alkaline bagasse emerging from the second mill is macerated with the alkaline juice from the fourth mill and runs into the third mill juice tank, where the stream of lime from the elevated tank mixes with it. The alkaline bagasse from the third mill is macerated with the alkaline sweet-water from the presses and after being pressed by the fourth mill, leaves it with practically no lime to speak of, due probably to the fact that the lime had a better chance of being pressed out of the bagasse in passing under the three sets of mills.

For purposes of control, the mixed juice going into the boiling house was kept acid. It remained, therefore, simply to set the stream of lime so that all the alkaline juices from the second, third, and fourth mills were not sufficient to make the whole mixed juice alkaline. This was done, as it was found more expedient to control the liming of the juices entering the boiling house at the scales, for, firstly, once the stream of lime was set at a certain rate it required no further attention; whereas had the control been conducted at the mills, extra help would have been required in addition to the scale boy, who controls the liming under ordinary conditions; and secondly, in analyzing a sample of raw juice first in its usual acid condition, and when it was alkaline by the addition of lime, it was found that there was a marked decrease in purities in the alkaline juice. For purposes of control, therefore, it was evident that an alkaline mixed juice sample would be in error.

As a result of this process, all sliminess, acrid smells, and sourness were remedied. The rolls took on a polished appearance, due to a slight slippage, though so far not to such an extent as to interfere with the feeding or render it impracticable.

This process of liming the mills is by no means new, as it is practiced in other sugar growing countries; control of the lime, however, is done at the mills. The method is simple and well worth recommending for trial. There seems no doubt that a certain amount of deterioration must be going on during the process of compound maceration. How much so far has not been estimated. Any loss that might be occurring, however, is not accounted for when juices are analyzed for the purpose of calculating the estimated sugar entering the mill and boiling house. For instance, suppose by analysis we find that the sugar entering the boiling house is 99 tons for the twenty-four hours, and that there is a loss of one ton in the bagasse. We are accustomed to assume that these two amounts added together of 100 tons, furnishes the amount of sugar coming into the mill. If there is a loss during the passage from the first to the last mills, as undoubtedly there is, it seems logical to suppose that this loss, however small, should be accounted for. Let us suppose it to be one ton; should not the estimated sugar entering the mill be 101 tons and not 100?

The mills at this company have always shown a small difference between the purities of the crusher and mixed juice, owing to the first mill being included, and possibly to the fact that the mills, being built on a grade, need no intermediate carriers and hence less souring is going on. During 1920 this difference was 2.2. During 1921, before liming at the mills commenced, it was 1.77, but after liming it decreased to 1.41. Whether this smaller difference was due to liming remains to be proved.

Clarification: Liming on the mills did not show any perceptible improvement in clarification, though where poor clarification is the rule a difference might be noticed. It is claimed that by this process clarification takes place as it were in the juice mixed with the bagasse, the impurities being carried into the fire room with the bagasse and not into the boiling house, thus relieving the juice of a certain amount of impurities. Heavier liming of juices at the scales resulted in a much darker colored clarified juice. As this darkness is usually

an indication of over-heated, over-limed juice, it should be reduced as much as possible. With this in view the temperature of the heater was brought down to 190° Fhr. Experiments on heater temperature during 1919 resulted in the juice settling very much slower when the temperature was reduced down to 190° Fhr. But considering that almost twice as much lime was now being added to the juice, it was thought that a temperature of 190° might be used with impunity. This deduction proved correct to a certain degree, and reduced the dark color to a clear, light one, without interfering with the rate of settling. Previously an alkaline juice could be easily detected without the aid of litmus paper by its darkness; since reducing the temperature to 190° the juice is clear, though distinctly alkaline.

During this experiment there was a marked increase in trash in the fire room. Whether this was due to the fact that less steam was being used at the heaters remains a question.

In referring back again to the table, it will be seen that the amount of lime added to the juice increased from 1.06 lbs. per ton cane to 1.891 lbs. The total recovery, after this addition, increased from 87.67%, when a neutral juice and no lime was used at the presses or re-settling tanks, to 92.6%, or an increase of 5%.

The foregoing experiments are well worth further trial. They may show that the fear of adding too much lime is unfounded; that by the addition of almost twice as much higher recoveries may result; that there is no cause for fear in over-liming if the temperature at the heater is kept down to 190° Fhr.; that boiling point at the heater is harmful; that by decreasing this temperature there will be an increase in trash; that the gravity purity of final molasses will be higher; that liming on the mills reduces decomposition, increasing the sugar output; that the estimated sugar should be based on the sugar at the crusher, and not on the total amount received at the boiling house plus that at the last mill, neglecting to account for that which may be lost over the mills during the process of extraction.

Combating the Field Rat.

NESTING HABITS.

A biological study of the nesting habits of the field rat is included in a paper pertaining to field rats in Java.* The study deals in a large part with the rice crop and the illustration reproduced herewith shows how the field rat takes advantage of the dikes in building a house that will not become inundated. We translate the description of the rat burrows, as follows:

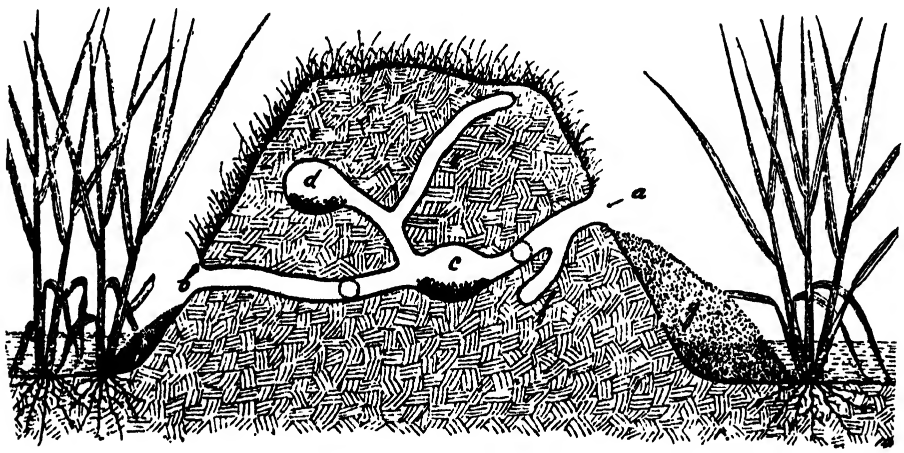


Fig. 1. A field rat hole in Java rice fields. a. Main entrance and exit. b. Secondary exit. c. Oldest nest room. d. Latest nest room. e. Emergency passage. f. Short, blind alley.

A field rat burrow (Fig. 1) consists of a more or less elaborate system of connected tunnels. In digging these tunnels the rats make good use of their strong, chisel-shaped incisive teeth; whereas their strong hind legs serve to throw the excavated soil outside. Mostly, but not always, the hole has several entrances and exits. The main entrance can be recognized immediately by the excavated crumbling soil which generally forms a cone-shaped heap under the opening. From here several of the smaller rat-trails run to the middle of the rice field. The other openings are sometimes so well hidden under all kinds of weeds that they easily escape notice. This should be kept in mind in a rat campaign.

The nest proper is made out of rice plant leaves and is a bulb-shaped widening of one of the subterranean passages (the so-called nest room), either closely under the surface or deep underground; sometimes at the beginning of a passage, other times clear at the end. For every new litter the mother rat builds a separate nest room.

Often the rat digs a tunnel running upwards, but stops just before the outside would be reached. When in danger the rat hides in this emergency passage and digs away quickly the remaining thin layer of soil and escapes. It happens very seldom that two or more rat holes are directly connected.

Characteristic is the peculiar habit of the rat mother, as a means of protecting her young ones, to plug up the main entrance, and sometimes the other openings as well; but this only for the time that the young cannot provide for themselves. The greatest care is given to the nest during the breeding period; before and after this period they serve the stray rats more as "pasanggrahans"

* Bulletin No. 16, by J. C. van der Meer Mohr. Institute for Plant Diseases, Department van Landbouw, Nijverheid en Handel. Quotations translated by W. H. Duker.

(government rest houses)—if we could call them thus—used only temporarily during their roving expeditions in times of food shortage. During the severe dry season the rats sometimes live in companies of fourteen and fifteen together in deep cracks in the soil.

Whether or not we are dealing with an occupied rat hole or one that is not can often be seen at the outside on several minor indications. For instance, the fresh footprints made in running in and out; fresh remains of food in the immediate neighborhood; and, furthermore, the before mentioned plug in the entrance. Old and unoccupied holes can quickly be recognized when the passages are filled with growing plant roots. As long as the rats live in these holes they keep them clean. The presence of mites in the nest straw points to the fact that the hole is still occupied or only recently left. The field rats do not keep food stores.

RAT DIET.

In contending with rats in rice fields much stress is laid upon the point that at the end of the harvest season, when food is scarce, active campaigns against these pests can be conducted to great advantage. It is stated that when the rice grain is scarce the rats turn to other crops, including sugar cane. This indicates, as we have thought, that rats in our fields in Hawaii may not depend on sugar cane as a sole, or even as the chief, source of diet, and that this is supplemented by other food material supplying protein.

We know of several instances where rodents have attacked cane in their search for animal food. The cane itself was not the primary object of attack, and the damage done was purely incidental. One of these cases was brought to our attention by E. L. Caum, who discovered a number of sticks of cane with large holes gnawed through the sheaths, exposing sometimes as much as a square inch of rind, and always at the nodes. In no case was the rind itself gnawed. The only explanation that can be offered is that the holes were made by mice in order to get the mealy bugs, which ordinarily congregate under the leaf sheaths at the nodes.

Another case was noticed a short time ago by Mr. Caum. In the course of experiments carried on with white rats in captivity, the animals were fed on cane only, to determine whether they could live on this limited diet. One stick given to them had been attacked by borers, and a large borer grub was then in the channel. The rats, which had had very little acquaintance with cane heretofore, immediately staged a mad scramble for that larva. After it had been consumed they gnawed out the cane joints through which the borer channel ran and made no attempt to eat any of the good cane until the partially fermented portion was completely cleaned out. In other words, they did not attempt to eat the cane as such until the last traces of animal food therein had been consumed. We know that many times borers follow rats, the holes gnawed by the rodents affording the insects easy access to the interior of the stick, but it appears that sometimes the rats might follow the borers.

RAT-CATCHING IN JAVA.

In discussing methods of combating the field rat, the Java report states:

As far as our knowledge reaches, the most effective and the simplest method is a systematic catching of the rats. The many experiments, already conducted by the Institute for Plant Diseases, with various poisons and bacteria prepara-

tions had little success. Excellent results therewith were sometimes reported from other countries, but here they never brought sufficient relief. In the meantime, the tests with poisons and poisonous gases are still continued, but for the present none of these remedies can be advocated for application on a large scale.

In the systematic drive for the rats a search is made for the rat holes and they are then hoed open; the fleeing animals are caught and killed. The only tools needed are a strong patjol (hoe) and a number of small bamboo traps. Such a bamboo trap is illustrated in Fig. 2. Any laborer can make a dozen of them in a spare hour. It is best not to make them too large, about 16 inches, with an opening not more than 2½ inches in diameter, on account of the fact that the diameter of the rat-tunnels is not much larger than that. Catching should be done in the early morning hours. To save time the rat holes should be located and marked the night before.

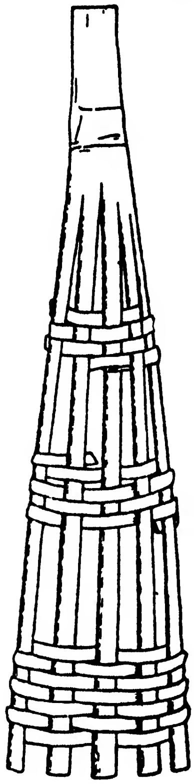


Fig. 2.
Bamboo rat trap.

First of all the nearest surrounding of the hole is carefully inspected (if necessary by cutting away all grass and weeds around the hole), to avoid chances of overlooking well-hidden tunnel openings. Furthermore, the catchers place a trap in every opening of the hole. Only now, after all these precautions are taken, may the coolies begin with their hoes. They must then try to cut open the tunnel over a short distance in a few blows. Immediately one of the helpers puts in another of the bamboo traps in the newly made opening, after locating, first, the direction of the tunnel, and then the cutting open process is continued. In this way the entire tunnel is cut open.

If it happens that the rat runs into one of the traps after the first blow, this is a stroke of luck; as a rule they hide themselves up to the last moment. However this may be, it is not advisable to quit until all tunnels are opened over the entire length. Even when finding an empty nest room, one should not give up; in many cases the mother rat, as soon as she notices danger, carries the young ones to another part of the hole. And so it may happen that several young rats may be found near the end of the tunnel, whereas the others are still in the nest room.

When a large area must be searched and when a sufficient number of men is available, it is best to divide up in groups of three or four men, each group to search a definite area and to make it rat-free; it is, of course, not advisable to have the groups too close together. In each group one man should be instructed to repair the damage done to the dikes or footpath. A well-trained gang of rat catchers working in this way can handle from six to ten rat holes per hour. Dogs can be made very useful in this work.

The question now is, when to start this catching? Are a few months of the year enough? Or should it be done all the year round? The last idea is not desirable at all, because any such measure, where a certain amount of enthusiasm is needed, slacks down when kept up too long. Besides this is not necessary.

The report then refers to the curve drawn herewith (Fig. 4), which represents the development of a definite field rat population for any given area of ample size.

The article which we are quoting calls attention to the fact that special overseers are needed to supervise the work of rat control, and that one month after

Fig. 3. Laborers in Java hoeing open a rat tunnel. The bamboo traps are set in the openings of the burrow.

the main catch the fields are searched once more for a period of two weeks for any of the rodents that may have escaped the real campaign.

Java, with its cheap and abundant labor supply, can adopt many measures which we cannot, and at first reading of the Java methods they seemed to be inapplicable to our problems. We have since been told by L. D. Larsen, Manager of Kilauea Sugar Plantation Company, who offers a bounty to his laborers for each rat that may be killed, that many of his Filipinos have adopted, on their own behalf, a system of digging out the rat burrows which differs only in degree from the one which is described for Java. The Filipinos at Kilauea, we understand, are aided in their undertakings by dogs. The bamboo traps here described have not been employed.

BURROWS IN HAWAII.

Before we had had the benefit of seeing the Java report, we undertook a little investigation to learn something of the nesting habits of the Hawaiian field rats. This work was in cooperation with the Honokaa Sugar Company. We were represented by Fred Hansson, whose report is presented in abridged form as follows:

The rats live mostly in burrows made in the ground. It is not often that any piles of soil are found outside the entrances to the burrows.* This seems to indicate that the rats make their burrows by pushing through the soil like a mole.

* This differs from the findings in Java previously quoted.

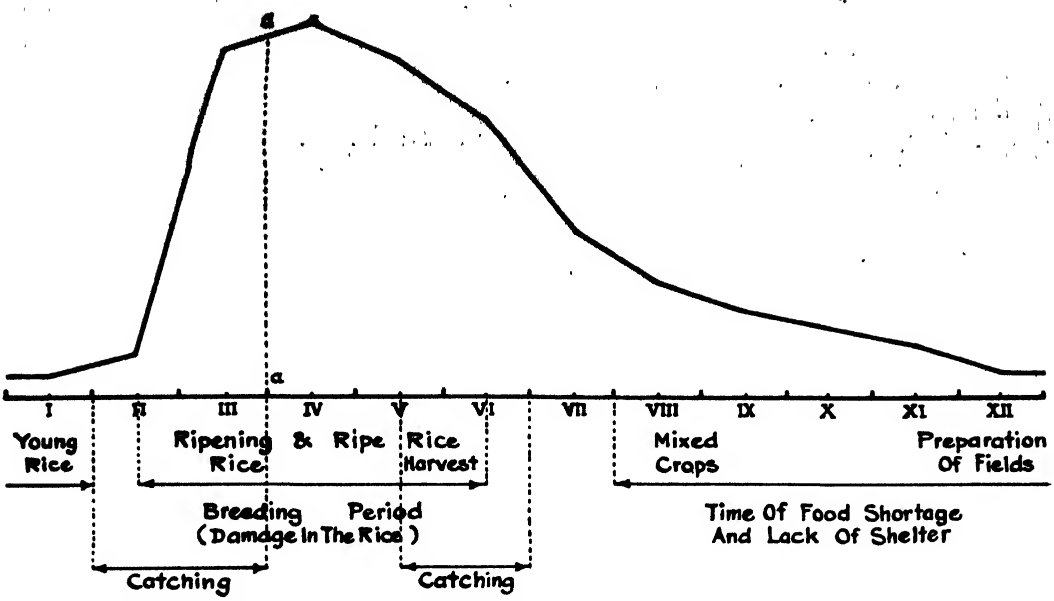


Fig. 4. This curve shows the rise and fall of the rat population under the conditions of the Java rice fields, and while such conditions are altogether different from Hawaiian cane fields, the curve is presented here to show the possibilities of biological studies which may result even under our conditions in showing what time of year is best suited for effective work of rat destruction.

The rising of the curve stands for the increase of the rat population in the breeding season; the gradual decline shows that this same rat population decreases due to a number of causes.

Another fact that bears out this theory is that the sides of these burrows are hard and tightly packed and easy to follow, while the surrounding soil is quite loose.

The rats like to make their homes where the subsoil is 18 inches or more below the surface. They push through the upper soil and make their nests at the junction of this and the subsoil, where the latter is not more than 24 inches below the surface. This lower soil is much harder than the surface soil and they do not dig into it very much. Wherever the surface soil is only 10 to 12 inches deep the rats do not make any burrows, but just go down to the subsoil and then stop. During our investigations we found several such holes.

There are always at least two entrances to the nest. Their burrows or tunnels vary greatly in length and the entrances are often five or more feet apart. In the gulches the rats live mostly in the rock piles or under boulders. A number of the burrows which had been treated with carbon bi-sulphide or cyanogen were dug out with pick and shovel. The sketches accompanying this report show the general types of arrangement of the tunnels and nests. It was found that the plan of the burrows varies with the location. It was noted that the entrances were nearly always located on the mauka side of the furrow. This was probably to avoid flooding the nest with rain waters.

The rats like to travel under cover. We found quite a number of tunnel-like places in the cane trash which showed signs of travel. They zig-zagged around and indicate that the rats stay hid as much as possible. After the cane had been cut, piled beside the flume and left over night, some of the rats would seek cover there. It is due to this habit that many were caught and killed by the dogs of the men who flumed the cane. One dog alone in one day killed twenty rats that had sought cover in the piled cane. Many rats are killed in this way during the course of a year.

The accompanying diagram (Fig. 5) shows the nesting habits of the Hawaiian field rats. An interesting point of difference is that we fail to find the blind tunnel described in the Java article.

POISONING EXPERIMENTS.

Gas.

Experiments were made bearing upon the possibility of poisoning rats in their burrows, after the practice commonly employed in contending with the ground squirrel in California. In connection with this work we had the benefit of the experience of G. R. Stewart, who has participated in work of this character.

The openings of the rat burrows, quite in contrast with those of the ground squirrel, proved to be very difficult to find, and until this obstacle is overcome, as perhaps it might be by the use of dogs, the possibilities of using poison gases in this way are not promising.

Our experiments were confined to eighteen burrows, all of which were found upon excavation to be empty. Mr. Hansson contends that rats enter the cane field after the stalk is well formed, say six feet long, and that it would be futile to gas the holes that might be found when the field is finally cleared of the crop.

A number of holes were gassed with carbon bi-sulphide and cyanogen. Most of them were treated the morning following the firing of the fields. In all cases the burrows were found empty. This clearly shows the rapidity with which the rats move to other areas.

Poisoned Barley.

The practice of the plantation in employing poisoned barley (the commercial preparation purchased in California, having strychnine as the toxic principle) has no doubt been effective in reducing the rat population. We learn from the California authorities that this barley is prepared specially for ground squirrels. which, in carrying the grain in the cheek pouch, absorb strychnine from the thin coat on the outside of the grain. This poison, thus absorbed, is said to be several times as effective as it would be if eaten and absorbed through the digestive channels.

The plantation has called our attention to poison grain that has freely sprouted in the field containers. It is claimed that this poisoned barley loses its toxic effect after exposure to moisture for a matter of fifteen days and that it is difficult to protect it from moisture under field conditions.

Miscellaneous Poisons.

An account of trials with other poisons and baits at Honokaa is given by Mr. Hansson as follows:

Squills, either in the powdered or liquid extract form, mixed with various baits, has been used with success in investigation in England and France. It is obtained from the bulb of a plant *(Scilla Maritima)*, which is found along the shores of the Mediterranean Sea and Southern Europe. We mixed the extract of squills with an equal part of milk and soaked enough oatmeal in it to form a dough. This was eaten very readily by the rodents.

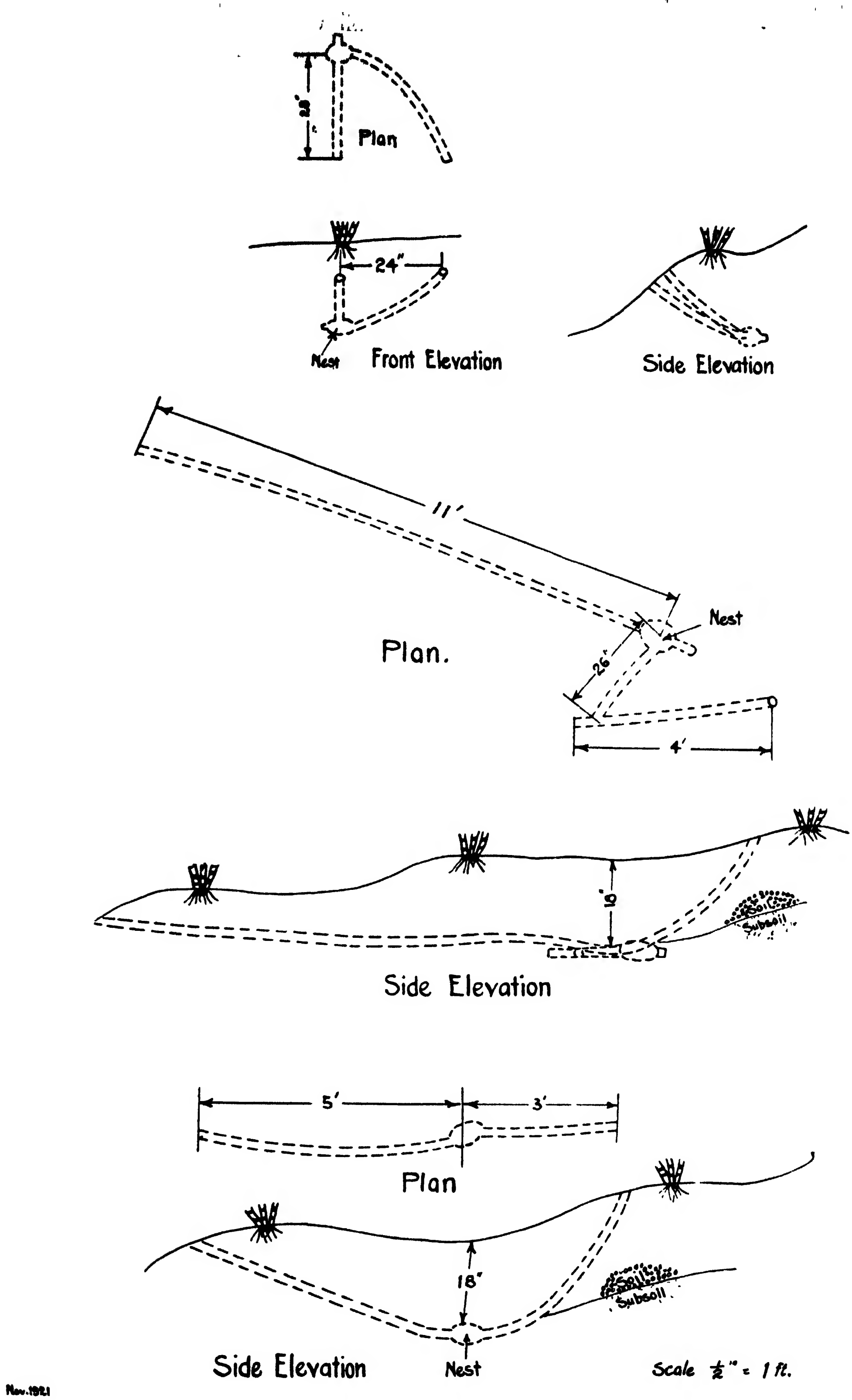


Fig. 5. Types of burrows in Hawaiian cane fields.

The powdered squills was ground up with tallow, and a portion of this mixture was combined with oatmeal, making a sort of oatmeal cake. This bait also was very palatable to the rodents and was soon consumed. We found, however, by experiments that it takes quite a long time for the squills to complete its work.

Some people suggested that molasses would make a good bait. We put out different mixtures using molasses as a bait. We mixed it with squills in both forms and also potassium cyanide. We found these materials all remained untouched.

Bi-chloride of mercury was mixed with tallow and spread on bread, but very little of this was eaten. This poison is very corrosive in its action and causes an irritation of the membranes of the mouth as soon as it touches them. It is therefore not surprising that even though the rats are fond of tallow, they did not eat this mixture.

Another poison we tried was barium carbonate mixed with various baits. This carbonate is an odorless and tasteless powder and is recommended by the U. S. Department of Agriculture. It is also used by the Indian Government in its work against rats. The plantation has tested barium carbonate more or less extensively, the present experiments being a continuation of that work. We mixed it with oatmeal; put it in cans in the dry state and placed them out in the field. This bait was eaten very freely by the rodents. Other portions were moistened with water and made into a sort of doughy mass. We placed this dough in the fields, and found that, while it was fresh, the rodents ate it very readily. It unfortunately molds rapidly and in that condition is eaten very sparingly. However, it can be molded into cakes and dried in an oven or any other convenient manner to improve its keeping qualities. This poison bait did not appear to lose its strength on standing. The whole grains of either oats or barley mix very well with barium carbonate and are very good baits. However, the rolled form of either grain appeared to be the best to use. This mixture is as easily made as are preparations with the whole grain and has the advantage that it can be molded into cakes that will not readily break apart. The best proportion appeared to be eight parts by volume of bait to one of poison.

Some other good features of barium carbonate are that it is very easily handled and is not particularly dangerous to human health or domestic animals. Although one to one and a half grains suffices to kill a rat, a chicken can take fifteen grains without injury and a dog one hundred grains. It is cheap and, unlike some of the other poisons, is partaken of very sparingly. The action of this poison starts soon after a small portion has been eaten. The rat then stops consuming the bait and goes in search of water. The poison attacks the lining of the stomach and causes a desire to drink, and for this reason is recommended as a good poison to use in buildings. We found by experimenting upon a captive rat that it took about six hours for this poison to complete its work.

TRAPPING.

Experiments with traps were also made. It was found that neither oil of rhodium nor oil of aniseed attracted rats to the baits, contrary to popular conception, and that aniseed, in fact, seemed to repel the rodents. Nothing was discovered to bear out the belief that rats shun traps which carry the scent of human handling. Many traps were found where the captives had been eaten by the mongoose. Evidence also showed that the rats attack and eat each other.

H. P. A.

Fiji Disease of Sugar Cane in the Philippine Islands.*

By Mariano G. Medalla.

Fiji disease of sugar cane, previously reported only from the Fiji Islands, New Guinea, and Australia, has been found in the Philippine Islands. It was found on the Island of Mindoro simultaneously by Professor Reinking of the College of Agriculture, University of the Philippines, and the writer. Later the disease was found in Laguna and Batangas Provinces and was there identified by Mr. H. Atherton Lee, just returned from Honolulu, where, through the kindness of Dr. H. L. Lyon of the Experiment Station, Hawaiian Sugar Planters' Association, he had the opportunity of examining preserved specimens of the disease from Fiji. There can be no question as to the identity of the disease.

The varieties Hawaii 109 and Java 247 are rather severely affected. Yellow Caledonia, Louisiana Striped and the native cane varieties Luzon White, Pampanga Red, and Cebu Purple were all affected, but at this time appear to have a slightly lesser degree of susceptibility.

In provinces where the disease is found, considerable losses have been caused on all of these varieties. One field of Yellow Caledonia plant was so severely affected that it was plowed under. In other fields, plantation managers estimate their losses at from 25 to 50 per cent, although the writer believes these losses possibly are a little over-estimated. The iosses from the disease are apparently increasing from year to year. The ratoon fields seem to show more of the disease than fields of plant cane.

To minimize or entirely prevent the losses from the disease, the following measures have been taken:

(1) The Plant Quarantine Board of the Philippine Islands has issued a regulation prohibiting the movement of all cane materials from Mindoro, Laguna, and Batangas Provinces. No case of the disease has been reported as yet in Negros, the large sugar-producing island; nor has it been reported from Cebu or Mindanao. In the absence of a definite report of the disease in those islands the domestic quarantine of the affected provinces seems justified.

(2) In cooperation with plantation managers in quarantined localities, steps are being taken to furnish seed points, from disease-free fields, to planters whose fields are affected.

(3) Through the kindness of Dr. H. L. Lyon, information has been made available concerning resistant varieties. Dr. Lyon states that Badila, Rose Bamboo, and Striped Singapore varieties, although not immune, exhibit a degree of resistance to the disease. These varieties are available at the Plant Pathology laboratories and will be distributed in small amounts to planters in affected localities. [L. O. K.]

* From Phytopathology, June, 1921.

Fertilizer Practices.

We note from a recent report of the Rothamsted Experimental Station at Harpenden that as a result of their fertilizer tests they are coming to the same conclusions in regards to the methods of fertilizer applications as we have arrived at here in Hawaii: that better returns are obtained from the use of relatively large amounts of fertilizer rather than by smaller amounts, and that the time of application has a very great bearing on the results. We quote the conclusions of their report.*

The results described in previous reports show that the output from the land is much increased by the proper use of artificial fertilizers on carefully selected suitable varieties of crops. In the case of cereals, good results have been obtained by the use of spring dressings of nitrogenous manures, these being required to replace the nitrates washed out during the winter. Experiments, however, show remarkable differences in effectiveness according to the time of application. It is impossible on present data to formulate hard and fast rules, but as shown below it appears that a small dressing (1 cwt. sulphate of ammonia or less) may go fairly late, while a larger dressing should go on early.

For many years the Rothamsted data have shown that the yield of crops increases with the amount of manure supplied, but beyond a certain point the increase is no longer proportional to the added manure. In the old experiments the unit dressing was 200 pounds of ammonium salts per acre, and the dressings were increased up to 800 pounds per acre. It was then found that the effect of the last 200 pounds of fertilizer, *i. e.*, of the increase from 600 to 800 pounds was very small and unprofitable, while the first 200 pounds had proved distinctly useful. This is in accordance with the Law of Diminishing Returns. It was assumed, therefore, that the law held for light as well as heavy dressings of manure and a deduction was made, for which the evidence was rather slender, that a small dressing of manure gave the largest profit, while further dressings gave a relatively smaller return.

Recent work, however, has disturbed this view. Two hundred pounds per acre of ammonium salts is too large a unit for modern practice, hence more interest attaches to the effect of the smaller than to the larger dressings. Examination of the Broadbalk results shows that the largest return is given, not by the first dressing, but by the second.

The conditions of an experimental field are not quite those of practice, and accordingly a new experiment has been started to see if under ordinary conditions of farming the highest rate of profit is given by good rather than by small dressings of fertilizers. The results of the first year (1920) suggest that this may be so.

* Report 1918–20 with the Supplement to the "Guide to the Experimental Plots," containing yields per acre, etc.

INCREASE IN WHEAT CROP, 1920, FROM SPRING DRESSINGS OF SULPHATE OF AMMONIA AND SUPERPHOSPHATE.

	Grain—Bushels per Acre			Straw—Cwts. per Acre		
Date of application of manure	Feb. 10	March 6	May 10	Feb. 10	March 6	May 10
Single dressing	Nil.	0.9	2.7	2.7	6.9	9.4
Double dressing	7.0	...	3.7	11.7	...	12.7

While the single dressing (100 pounds sulphate of ammonia per acre) gave no appreciable increase in grain, and only a fews hundredweights of additional straw, the double dressing gave increases of no less than seven bushels of grain and twelve hundredweights of straw. Late application of the double dressing, however, was risky, giving an unhealthy straw, liable to lodge and prone to disease. [J. A. V.]

The Human Element in Power Plants.*

Human interest or personal touch has been sadly neglected in many dealings with power plants and power-plant apparatus; this is one reason why, perhaps, so many are operated as they are, why the operating force so often fails to receive the recognition accorded other workers, and why the power plant is too often a thing apart. Perhaps the engineers themselves are largely to blame for this. The work of the power plant necessarily serves to isolate its workers; the functioning of the plant is such that only those most closely in touch with its *modus operandi* appreciate and understand them. As a consequence it is left to itself because the factory or organization managements know little about it and because the power-plant personnel, as a rule, make little or no effort to make themselves or their work known.

A trip was recently made through a factory in company with the president, who prided himself upon the extent to which he had introduced the human interest or personal touch in his organization. A cafeteria and rest rooms for the employees had been provided, there was a tennis club, a mutual benefit association, group insurance, a visiting nurse and similar welfare activities to show that the employer had the interest of the employees at heart. Working conditions were good, including ample light, generous ventilation, individual lockers, shower baths, etc. A form of employees' representation had been adopted, as showing, further, that human interest and personal contact are vital phases of present-day industrialism.

After the inspection of the factory, and on the way back to the office, the president was asked why he had not shown the power plant—the heart of the establishment. He replied that he had forgotten about it; he rarely visited it, because it was hardly part of the factory proper and was so troublesome anyway.

* From Power, Vol. 54, No. 14, p. 533.

As might be surmised from the remarks made, the plant had never had much of a chance any more than had its personnel. The boiler room was dark and cramped, apparatus was run down, and the whole place looked uncomfortable. Doubtless performance was in keeping with environment. There was nowhere for the men to sit down and rest and reason things out, notwithstanding that the modern plant requires brain more than it does brawn. There was no adequate place for the men to change their clothes or wash. There was no special place to eat. There was nothing to make the plant fit for human habitation or encourage good work.

"How is it," the president was asked, "that you have carried your employees' welfare so far in your factory and yet apparently have done nothing in the same direction in your power plant?" "Oh," he said, "it is pretty difficult to do anything here, because these fellows are hard to please. They do not seem to mix with the rest of the employees, and anyway, I hardly consider this part of the plant."

This little incident holds true for numerous plants—and the more's the pity. The managment does not think; it divorces its power plant from the rest of the establishment notwithstanding that the entire works depends upon the functioning of the power plant and the loyalty of its workers.

The engineer who obtains the viewpoint of those that must pass on his suggestions is more likely to "sell" his ideas than the one who sees only his own viewpoint. There are different ways of explaining a thing, and very often the less technical it is the better. Introduce the personal element, or human interest.

Insist on being "one of the boys" when it comes to employees' welfare. If the company issues a house organ, make it a point to have brief mention of the power plant, what it is doing and who comprise the personnel. It pays to advertise. A little insistent publicity in a legitimate way, telling of the good work the men are doing, how admirably the plant is accomplishing its task and similar "human interest" propaganda will do wonders in winning the recognition that the power plant and its crew usually deserve. [W. E. S.]

The Aeroplane in Agriculture and Forestry.

That agriculture is to benefit from aeronautics is now evident from recent developments along this line. The use of the aeroplane in patrolling forest reserves on the mainland, in connection with the detection and control of forest fires, has been perfected and is now in common practise. Using aeroplanes for dropping tree seed in the reforestation of cut over timber land, we understand has been proposed, but we do not have at hand information as to whether this has been employed in practise.

The aeroplane has other uses in agriculture, one of which extends to economic entomology. An article entitled, "Spraying Trees From an Aeroplane," from the "Aerial Age," August 29, 1921, reads:

The novel experiment of spraying a grove of trees from an aeroplane, the first ever attempted in the United States, was made on August 4 over the farm of Harry A. Carver, near Troy, Ohio, to prevent further ravages of worms which have twice practically defoliated this grove of 5000 Catalpa trees. The plane, piloted by Lieut. Johan A. Macready, Air Service, and carrying E. Dormoy, McCook Field, designer, who constructed the sifter used to spray the arsenate of lead powder, flew within 20 or 25 feet of the top of the trees, releasing the powder which was carried by the wind and air currents from the ship's propeller into every part of the grove.

Treatment of trees in this manner saves much time and labor, as an aeroplane in a few minutes can do work which would require a number of men and many pump sprays several days. The effect of this experiment will be watched with interest by entomologists and forestry experts in many parts of the country, especially in the east, where a similar scourge is working havoc with many magnificent elm trees. The idea of utilizing an aeroplane for this purpose originated with C. R. Neillie, of Cleveland, who came to Troy to witness the first trial. H. A. Gossard, Chief of the State's Department of Entomology, also came to witness and assist in the experiment.

Mr. Dormoy is understood to be working on a new hopper which will simplify spraying of the powder, and McCook Field officials have indicated their willingness to cooperate with farmers and with the Department of Agriculture in combating insects and tree infection.

This experiment connects in an interesting way with the recent work of our entomologists in employing dust insecticides as a substitute for liquid sprays in leafhopper control. Experiments conducted by H. T. Osborn showed that a nicotine dust preparation had certain advantages over solutions based on the same ingredients.

It is not unreasonable to suppose that some adaptation of the method of controlling worms in Catalpa trees, with arsenate of lead, may be applied in employing a nicotine dust to control obstinate outbreaks of leafhopper, in the event that these should continue to recur. The expensive equipment required would perhaps be offset by the vast area that could be covered in a short time by aeroplane. The spraying or dusting of cane one to two years old has never been feasible and perhaps these new uses of aeroplanes offer a solution.

Dr. H. L. Lyon, George A. McEldowney, and the writer have discussed the possibility of employing aeroplanes for sowing tree seed over watersheds where the native flora is in a depleted condition. Plans for experiments in this direction are now being discussed with the Hawaiian Department of the U. S. Army and the Board of Agriculture and Forestry. H. P. A.

Clarification.

By W. R. McAllep *and* H. F. Bomonti.

Increase in Purity.

During the last few years the increase in purity from mixed juice to syrup in Hawaiian factories has been steadily decreasing. Since 1918, the average shown in the Annual Synopsis of Mill Data has decreased from 1.79 to 1.13. This investigation of clarification was begun, largely, because of the apparently poorer average results secured and because of differences of opinion as to the preferable way of conducting the clarification.

The first juices examined were from the Experiment Station plots in Honolulu. Afterwards mixed juice samples from different Oahu factories, the greater part of them, however, from Honolulu Plantation Co., were studied. Later a few samples of juice that gave trouble in factory practice on account of poor settling were secured. The juices can be divided into two fairly distinct classes, those clarifying well and on settling leaving a comparatively clear juice and those in which lime and heat failed to produce a satisfactory clarification, leaving turbid settled juice. Increases of from 2.5 to 4.0 points in apparent purity have been secured in juices of the first class. Juices of the second class have not yet been thoroughly studied. Much smaller increases in purity were secured, however, than in juices giving a satisfactory clarification.

A close estimate of the size of the possible increase in purity comparable with the Annual Synopsis figures for the actual increase cannot now be made. The juices studied were drawn from a somewhat limited area; a considerable proportion of them from a small area, and there is but little information indicating what proportion of the whole is made up of the second class of juices. Data now available, however, show the characteristics of the first class of juices at different reactions of the clarified juice and also how clear clarified juices can be secured from juices of the second class. For this reason it seems advisable to publish these data at the present time, rather than to wait till some of the details can be more thoroughly studied.

The increases in purity herein reported are comparable with increases in purity from mixed to clarified juice, rather than with increases in purity from mixed juice to syrup, ordinarily referred to when the term is used. We would note, however, that the latter ought to be larger than the increase in purity from mixed juice to clarified if the clarification, filter press work, etc., is carried on so that no deterioration or inversion takes place, because of the well-known tendency of the polarization to increase in proportion to the sucrose during clarification, evaporation and boiling.

Two major factors contribute to the increase in apparent purity from mixed to clarified juice shown by the routine chemical control. These are the mechanical and the chemical removal of solids from the juice. A third factor in heavily limed juices, is the increase of polarization in proportion to sucrose.

Mechanical Increase in Purity.

Mixed juice as it comes from the mill contains suspended matter in amounts varying with the mill equipment, the amount of soil adhering to the cane, and the thoroughness with which the juice is screened. This suspended matter varies in size from the largest particles that can pass the mill screens to colloid dispersions of ultramicroscopic dimensions. Without further discussing the classification of colloids, we consider it proper to include colloids that contribute to the mechanical increase in purity with the suspended solids because they are of sufficient size to be removed by filtration without resorting to coagulation or other means to reduce their degree of dispersion.

Though the suspended solids are not in solution they influence the solids determination. If this is made by drying, they affect it to the same extent that they would if they were in solution. If it is made with a hydrometer the effect is less, corresponding to the amount that the apparent specific gravity of the juice is increased. The latter effect will also vary according to the manipulation. If the juice is mixed immediately before determining the brix, the maximum effect will be obtained. If the juice is allowed to stand, the effect will be smaller according to how completely the suspended matter has settled when the hydrometer reading is made. The brix of a juice before clarification is then somewhat indefinite, but is always higher than the brix due to the solids actually in solution. The purity calculated from this brix will, therefore, be lower than the actual purity, or ratio of sugar to dissolved solids.

The suspended matter including all but a very small proportion of the colloids can be removed by filtration. After such filtration the brix can be considered as that due to the dissolved solids and the purity calculated from this brix, the ratio of sugar to dissolved solids. The "mechanical" increase in purity is the difference between this purity and the purity as determined on the unfiltered juice.

The "mechanical" increase in purity has been determined on a considerable number of juices in this investigation. The mixed juice samples were allowed to stand for half an hour or more and when necessary the surfaces cleaned by flooding before determining the brix. Suspended matter that had passed the mill screens was not removed. The following filtration method was used: A liter of juice was mixed with approximately 50 grams of kieselguhr and filtered over reduced pressure through a Buchner funnel prepared in the following manner: A disc of 24 mesh brass screen, 9 cm. in diameter was placed in a 15 cm. funnel and covered with a moistened, rather heavy, 12.5 cm. filter paper. When vacuum was applied, the edges of the moistened paper were drawn down forming a seal. The filtration of a liter of juice was usually complete in between one and two minutes. The filtrate was then passed through a second funnel similarly prepared, except that a hardened filter paper was used. The second filtration was usually completed in from 10 to 15 seconds. After filtration, by this method, juices are limpid and apparently free from suspended matter. When examined by the "Tyndall cone," that is a beam of light passed through the juice in a darkened room, the cone is distinctly visible and the dispersed light is polarized, indicating that this filtration does not completely remove the colloids.

The following tabulation shows the average mechanical increases in purity obtained in juices from different sources, and also a comparison with the maximum increase obtained on clarifying the unfiltered juice with lime:

TABLE I

Mill	Number of Samples	Increase in Apparent Purity		Mechanical % of Total
		Mechanical	Total	
Experiment Station	16	0.46	2.89	16%
Honolulu Plantation Company 1	7	0.97	2.96	33%
Honolulu Plantation Company 2	1	0.3	2.9	10%
Waialua	2	0.5	2.69	19%
Ewa	2	0.6	2.8	21%
Waimanalo	1	0.6	0.8	75%
Average	..	0.58	2.72	21%

The juices marked "Experiment Station" were expressed in a small three-roller mill at the Station. All other samples, with the exception of Honolulu Plantation No. 2, were mixed juice, as it was sent to the boiling house at the factories named. The sample designated Honolulu Plantation Co. No. 2 was mixed juice after passing through a 100 mesh screen.

The size of the mechanical increase in purity in juice from the different sources follows somewhat closely what might be expected from the milling and screening practice. That is, where the practice is such that large quantities of suspended matter would be expected in the juice, the increase is larger than where smaller amounts are probable. At the Experiment Station there is no screen, but the milling is very light. The cane is shredded at the Honolulu Plantation and the screen is coarse. At Waialua and Ewa the cane is rather finely divided, the milling heavy, and the screens fine. At Waimanalo the milling is light and the screen coarse. Referring to the sample marked "Honolulu Plantation Co. No. 2," it will be noted that removing the suspended solids retained on a 100 mesh screen, reduced the mechanical increase in apparent purity to one-third of the average value found in other juices from this source.

Zerban[1] found an average mechanical increase in purity of 0.45 in seven determinations. He also concludes that "the 'mechanical' side of clarification is infinitely more important than the 'chemical effect.'" The mechanical increases in purity shown in Table 1 agree reasonably well in size with those found by Zerban, with the exception of the juices from the Honolulu Plantation.

The ratio mechanical increase in purity to total increase obtained by lime, heat and filtration, appears in the last column of the table. The sample of juice from Waimanalo is the only one in which the mechanical is the larger part of the total increase. This was a juice of the second class. It did not clarify well and the total increase in purity was small. Juices from Honolulu Plantation, with an average of 33%, show the next largest percentage of mechanical to

[1] Louisiana Bulletin No. 173.

total increase. High individual samples of these juices were 38.5, 41, and 50%, respectively. All other juices listed in the tabulation show a much smaller ratio. The average of all determinations was 21%. It is probable that this figure is representative of Hawaiian conditions, though present information is too limited to justify a definite conclusion to this effect. The reason this figure differs so much from the 72% found by Deerr[2] is that in obtaining it, solids were determined with a hydrometer as in factory practice, while Deerr determined solids by drying. Comparisons of the mechanical increase in purity in experiments such as Deerr's, where the solids are determined by drying, with increases in purity shown by the ordinary control figures, where the solids are determined with a hydrometer, are misleading. The proportion that the mechanical bears to the total increase in purity shown by the control figures is less than would be inferred from such experiments.

The mechanical increase in purity cannot be regarded as a real increase in the sense that the ratio of sugar to dissolved solids has been changed. It is rather to be regarded as due to an error in the methods of analysis in the case of juice containing suspended matter, caused by the effect of this suspended matter on the solids determination. It is, of course, necessary to remove suspended matter from the juices before continuing with the manufacturing process, but when increases in purity due to chemical treatment as large as those shown in the table are secured, Zerban's conclusion that "the mechanical side of clarification is infinitely more important than the chemical effect" seems hardly justified from the standpoint of the manufacture of raw sugar.

Though the proportion of suspended matter remaining in a well clarified juice is comparatively small, all of the mechanical increase in purity will not be realized in ordinary clarification for two reasons. First, the remaining suspended matter will depress the clarified juice purity slightly. We have found a maximum difference in purity of 0.2 before and after filtering a well clarified and settled juice in the manner previously described. The average of a number of determinations is less than 0.1. Second, the suspended matter is subjected to the action of lime and heat before its removal, such action dissolving a part of the fiber. This subject has been treated in a recent article.[3] This factor will normally be larger than the first. While there is not a definite quantitative relation between the amount of suspended matter present in the mixed juice and the depression of the purity, such data as are available at present seem to indicate that the solution of suspended matter during clarification can offset from a third to a half of the mechanical increase in apparent purity.

Chemical Increase in Purity.

The chemical increase in purity in the lime defecation process is due to the precipitation of soluble solids from the juice by the action of heat and lime. Gums, proteids, phosphates and bases with the exception of alkalies are precipitated. Colloids are coagulated and settle, together with the greater part of the

[2] Record, Vol. 19, page 50.
[3] Record, Vol. 25, No. 3.

remaining suspended matter, except the portion of the latter dissolved by the lime, the settling being facilitated by the heavy precipitate of phosphates and bases.

While much has been written on clarification, the possible increase in purity has been given minor consideration. Opinions expressed as to its size vary from one to four points, these opinions, no doubt, being influenced by the quality and composition of the juices that have come under a particular writer's observation.

This investigation of the chemical increase in purity has been directed principally toward obtaining data applicable to Hawaiian conditions regarding the effect of varying amounts of lime on the purity and determining under what conditions the maximum increase in purity can be secured. The work has been carried on in a manner approximating as nearly as practicable factory conditions, and the results expressed so as to be closely comparable with control figures. To this end the juices have been clarified in the presence of whatever suspended matter they happened to contain, reactions are referred to litmus as an indicator, and results are expressed in terms of apparent purity. The relation of increase in apparent to increase in gravity purity and the relation of litmus to phenolphthalein reaction have also been studied.

The general procedure has been to clarify liter portions of a sample of juice with different amounts of lime, to obtain a series of clarified juices preferably running past the point where the maximum increase in purity was secured. The limed juices were boiled, allowed to settle on a steam bath for an hour to an hour and a half, and filtered in the manner previously described. Analyses were made by the dry subacetate of lead method. The above procedure is the equivalent of factory practice, with the exception of the filtration. Filtration was more convenient than attempting to decant the comparatively small amounts of juice used and a higher degree of accuracy in analyses was obtainable with the disturbing effect of suspended matter eliminated. As previously noted the filtration has a slight effect only on the apparent purity of a well clarified and settled juice.

The litmus used in titrations is in the form of a sensitive non-absorbent paper [4] prepared for this purpose. The procedure was to add the standard solution to the sample in small portions till the neutral point was passed, a drop being placed on the paper after each addition. After the last addition of standard solution, the drops were shaken off, leaving a row of spots graduated in color from red to blue. The neutral point can be determined with a high degree of accuracy. The color of the solutions does not interfere. Solutions as dark as molasses can be accurately titrated by this method.

Reactions have been expressed in per cent CaO; that is, CaO equivalent to the amount of standard acid or alkali necessary for neutralization, calculated to percent on the juice. This is a method of expression that has become conventional in the beet industry. The method of expressing reactions sometimes used in the cane industry, cubic centimeters of normal acid or alkali per 100

[4] Papier Reactif Tournesol Sensible, made by Ch. Gallois & Fils.

cubic centimeters of juice, may be converted to this standard by multiplying by .028.

At present, data for twenty clarification series are available. With one exception these juices were of the class that clarify and settle satisfactorily. Though a few samples of the other class have been secured, to date the work on such samples has been directed principally toward finding the reason for the characteristics shown by them, and but one at all complete series showing the purity at a number of different reactions is available. As the clarifications were made in the presence of suspended matter the whole of the mechanical increase in purity was not realized and the figure obtained by subtracting the mechanical from the total will be smaller than the actual chemical increase. This applies particularly to figures for gravity purity. In apparent purity the effect of not realizing the whole of the mechanical increase on the figure for chemical increase is offset to a greater or less extent by the change in the ratio of polarization to sucrose.

The following tabulations and graphs are with reference to juices that clarify satisfactorily. Table II and Figure 1 show the results of an experiment where a large increase in purity was secured. The juice was Lahaina from Honolulu Plantation Co. The low purity of this juice was due to delayed harvesting. We would note that the inspection of all available data does not indicate any apparent connection between low purities due to this cause and the size of the possible maximum increase in purity. However, if only sufficient lime is added to result in a clarified juice neutral to litmus the tendency is for the increase in purity to be very small. In this case the increase in purity at the neutral point to litmus was but little larger than was obtained by filtration alone.

TABLE II

Treatment	Reaction Litmus	Reaction Phenol-phthalein	Purity		% CaO
			Apparent	Gravity	
Mixed Juice	.012 acid	.085 acid	75.52	77.54	....
Filtered	.012 "	.085 "	76.37	78.50	.030
2 cc. lime	.003 "	.069 "	76.43	78.35	.027
4 " "	.003 alk.	.050 "	76.75	78.68	.026
6 " "	.006 "	.029 "	77.53	79.49	.025
8 " "	.008 "	.012 "	78.60	80.20	.033
10 " "	.010 "	.007 "	78.90	80.43	.042
12 " "	.012 "	.005 "	79.14	80.66	....
14 " "	.013 "	.004 "	79.22	80.63	.065
16 " "	.015 "	.002 "	79.61	80.65	.081
18 " "	.017 "	0	79.86	80.92	.089
20 " "	.020 "	.003 alk.	79.14	80.20	.102

Purities and lime salts are plotted against reaction to litmus in Figure 1. The scales for purity, lime salts, and reaction to litmus are respectively at the left, right, and bottom of the graph. Figures opposite points on the apparent purity curve are for reaction to phenolphthalein. Underlined figures for reaction indicate acidity. The figures at the bottom immediately above the scale

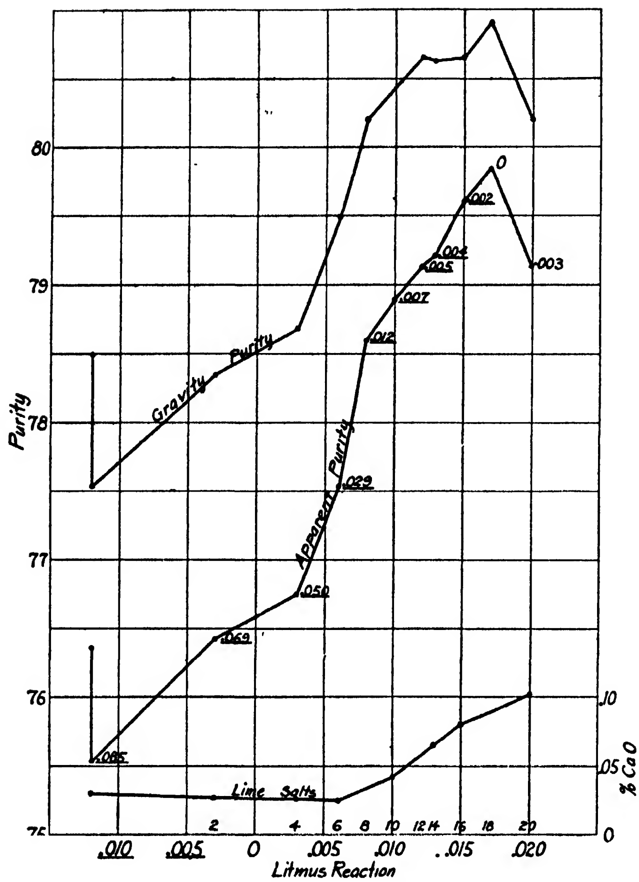


Figure 1.

for litmus reaction indicate the cubic centimeters of a 10· brix lime suspension used. Mechanical increase in purity is indicated by vertical lines joining the left of the purity curves. As noted above, the increase in purity at the neutral point to litmus is but slightly larger than the mechanical increase in purity. The steepest part of the purity curve is between neutrality and .008 alkalinity to litmus. From the latter point to phenolphthalein neutrality the curve is somewhat flattened. In this portion of the curve, comparatively large amounts of lime were required to make a small change in reaction either to litmus or phenolphthalein. The maximum increase, both in gravity and apparent purity, is at the neutral point to phenolphthalein. After this point is passed the purity curves decrease sharply. The increase in gravity and apparent purity is approximately the same to .006 alkalinity to litmus. From .006 to .008 the two curves show a slight tendency to converge. From the latter point to the neutral point to phenolphthalein this tendency is much more pronounced, and indicates that between these points some 50% of the increase in apparent purity was due to the precipitation of impurities and 50% due to a change in the ratio of polarization to sucrose. The two curves converge much more rapidly after the neutral point to phenolphthalein is passed. The increases in apparent purity in this series were: mechanical, 0.85, and total, 4.34. In gravity purity the figures were: mechanical, 0.96, and total, 3.38.

In this experiment the lime salts decreased slightly up to .006 litmus alkalinity. At .008 they were close to the original amount, increasing after this point till at the neutral point to phenolphthalein they were three times the original amount. The increase in lime salts at phenolphthalein neutrality to three times the original amount is in good agreement with other experiments on juices of the class that clarify well. The slight decrease shown in the more acid members of the series is rather exceptional.

In this experiment two points of particular interest are fairly sharply defined. These are: .008 alkalinity to litmus, corresponding to .012 acidity to

phenolphthalein, and neutrality to phenolphthalein. At close to the former point examination of the ash indicated that precipitation of phosphates and bases was finished. This was also the point where lime salts began to increase rapidly. Up to this point the change in reaction to phenolphthalein and the amount of lime used were in a definite proportion. Past this point the same amount of lime caused a much smaller change in this reaction. If purities are plotted against the amount of lime used, a definite change is noted at this point. On the acid side 1 cc. of the lime suspension used caused an increase of approximately 0.35 in both apparent and gravity purity. Between this point and neutrality to phenolphthalein the same amount of lime caused an increase of 0.12 in apparent and 0.07 in gravity purity. The neutral point to phenolphthalein is of particular significance because here the maximum increase in gravity and apparent purity was secured, and here also another marked change in the relation of gravity to apparent purity occurred.

Table III and Figure 2 contain the data of a series on juice from H 5001 cane grown at the Experiment Station plots. This is a case where a large increase in purity was secured in juice of about average purity.

TABLE III

Treatment	Reaction Litmus	Reaction Phenol-phthalein	Apparent Purity	% CaO
Mixed Juice	.016 acid	.080 acid	83.43	.021
4 cc. Lime	0	.060 "	85.84	.025
8 " "	.006 alk.	.034 "	86.34	.025
12 " "	.010 "	.008 "	86.51	.033
16 " "	.012 "	.002 "	87.16	.038

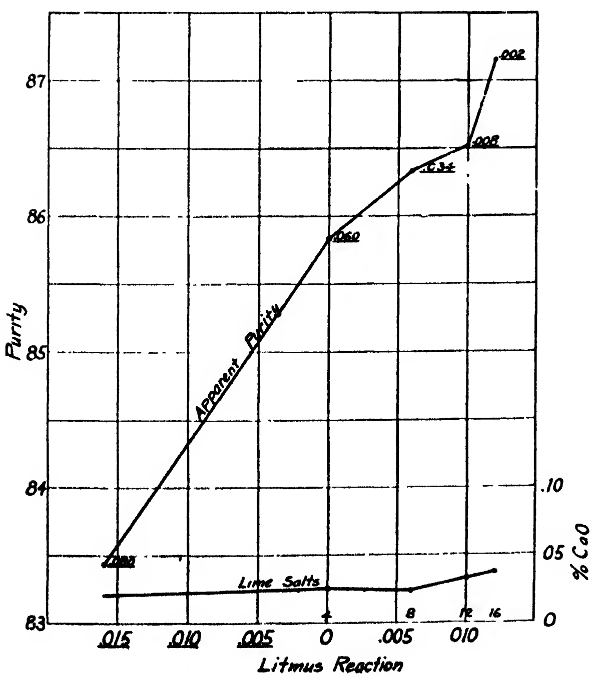


Figure 2.

Though a large increase in apparent purity, 3.73, was secured in this series, it is not certain that this approximated the possible maximum, for neither neutrality to phenolphthalein nor a point showing a decrease in purity was reached. This series differs from the preceding, in that a large increase in purity was found at the neutral point to litmus. Also the increase at this point was a very much larger proportion of the total increase. Lime salts increase slowly at first and afterwards rapidly, the point where the change occurs agreeing closely with the corresponding point in the preceding series.

Table IV and Figure 3 are data for a series in which a somewhat smaller increase in purity, 2.53, was secured and in which the addition of lime was carried considerably beyond the neutral point to phenolphthalein. The juice was D 1135 from Oahu Sugar Co. The purity was low on account of delayed harvesting. In this connection it will be noted that the increase in purity at the neutral point to litmus was very small.

TABLE IV

Treatment	Reaction Litmus	Phenol-phthalein Reaction	Purity		% CaO
			Apparent	Gravity	
Mixed Juice	.012 acid	.064 acid	78.38	.....	.035
3 cc. Lime	.002 alk.	.021 "	78.50	.....	.041
6 " "	.010 "	.014 "	79.50	.....	.056
9 " "	.014 "	.004 "	79.67	81.44	.071
12 " "	.020 "	0	80.91	82.30	.097
15 " "	.028 "	.003 alk.	80.89	81.92	.110
18 " "	.034 "	.005 "	80.73	81.52	.127
21 " "	.038 "	.006 "	80.73	81.48	.152
24 " "	.044 "	.008 "	80.67	81.25	.176

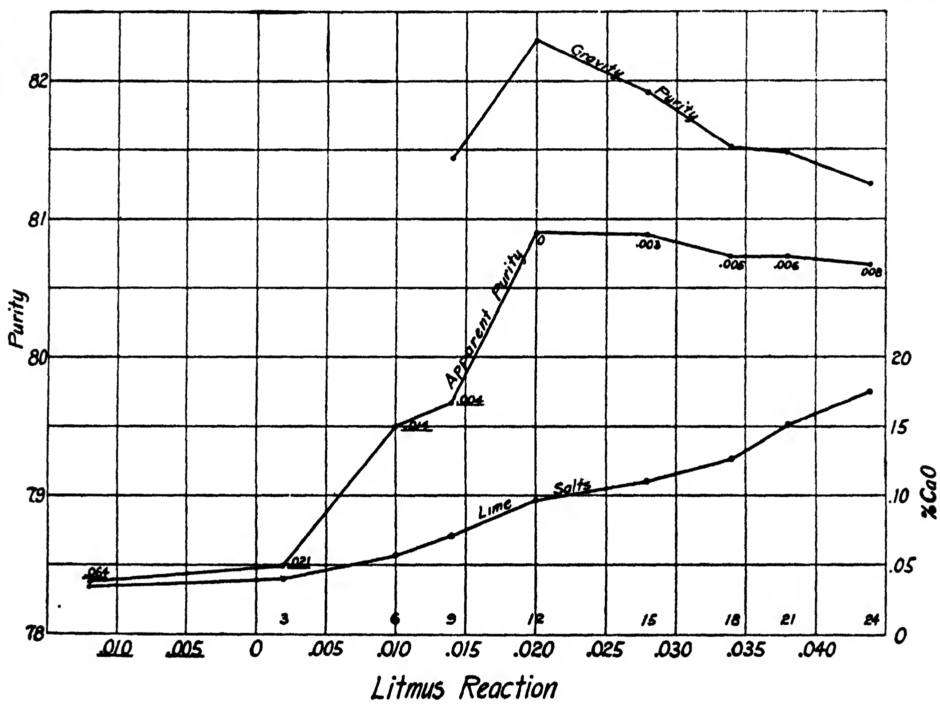


Figure 3.

The maximum increase in both apparent and gravity purity was at the neutral point to phenolphthalein. Past this point there was a gradual decrease in apparent and a rather rapid decrease in gravity purity. The relation of gravity and apparent purity is similar to that shown by the curves in Figure 1. In the portion of the curve immediately on the acid side of the neutral point to phe-

nolphthalein, some two-thirds of the increase in apparent purity is confirmed by the increase in gravity purity.

The lime salts, plotted in Figure 3, begin to increase rapidly at a lower alkalinity than in the two preceding experiments. However, no points are available between .002 and .010 litmus alkalinity. Comparison with other lime salts curves indicates the probability that the change in the lime salts curve would be shown at .006 to .007 litmus alkalinity were these points available.

At phenolphthalein neutrality lime salts were some three times the amount originally in the juice. On the alkaline side of this point the lime salts continue to increase rapidly.

Table V and Figure 4 show data for a series in which an increase in apparent purity of 2.69 was obtained in a very high purity juice. The juice was from Waialua Agricultural Co., and resulted from Yellow Caledonia cane.

TABLE V

Treatment	Reaction Litmus	Reaction Phenol-phthalein	Apparent Purity	% P_2O_5
Mixed Juice	.010 acid	.078 acid	88.46	.074
Filtered Juice	.010 "	.078 "	89.13	.074
2 cc. Lime	.004 "	.058 "	89.37	.059
4 " "	.006 alk.	.038 "	89.76	.023
6 " "	.010 "	.024 "	89.92	.005
8 " "	.016 "	.014 "	90.01	.005
10 " "	.020 "	.007 "	90.50	.005
12 " "	.024 "	.001 alk.	91.15	.005

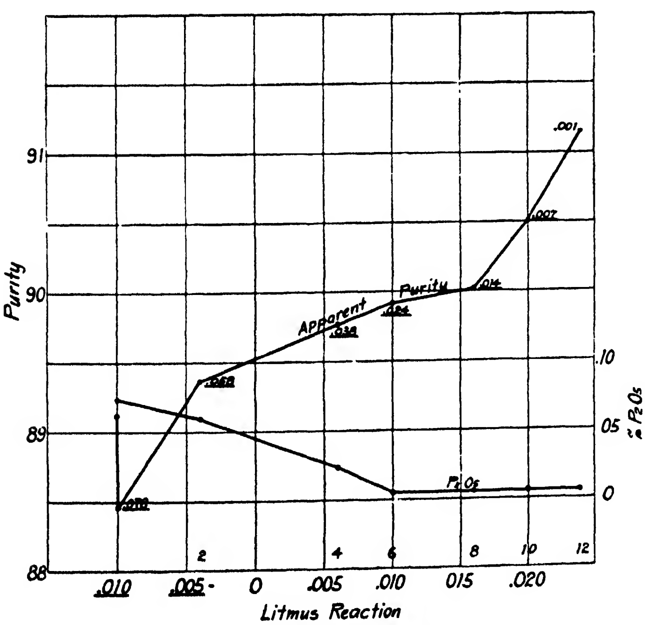


Figure 4.

Though the neutral point to phenolphthalein was passed, the most alkaline juice of the series was the highest in purity, and it is not certain that the maximum was reached. A fair increase in purity was secured at the neutral point to litmus. Lime salts were not determined. In this case the lower curve is the P_2O_5 content. The precipitation of P_2O_5 was in proportion to the change in reaction to litmus, stopping at .010 alkalinity, at which point the percentage was reduced to .005.

The twenty series have been averaged and the results shown graphically in Figure 5. Points in the purity curve were located in the following manner. The

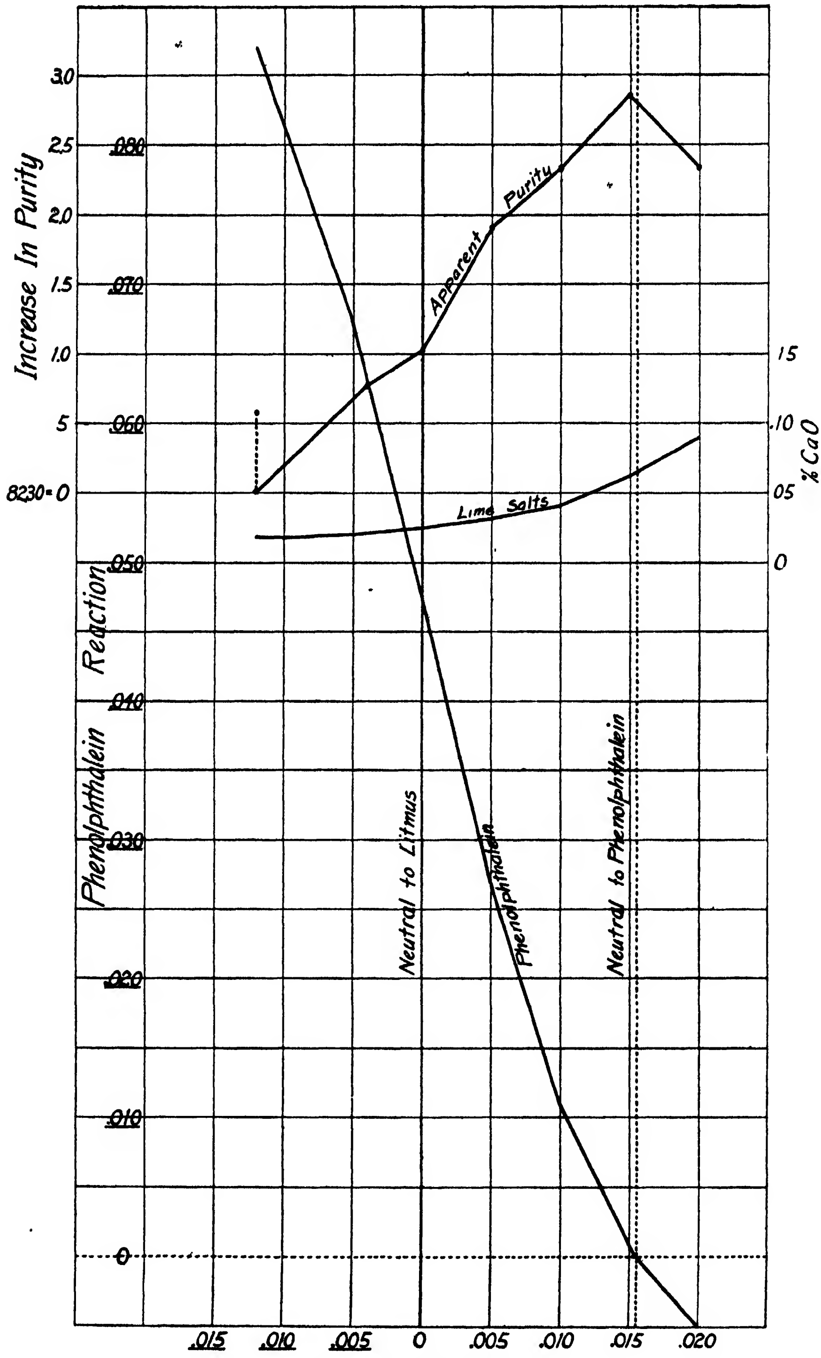


Figure 5.

average acidity of all the original juices was taken as the starting point. Above this the average mechanical increase in purity was plotted. Next all clarified juices between .007 and .003 acid to litmus were averaged and plotted. This range included all the more strongly acid of these juices. The points for juices

between .002 acid and .002 alkaline to litmus, .003 and .007 alkaline, etc., were located in the same manner. The curves for lime salts and phenolphthalein reaction were similarly constructed.

The curve for apparent purity rises rather sharply to the neutral point to litmus, the increase in purity indicated being due to a considerable extent to the removal of suspended matter. The steepest part of the curve is just past the neutral point to litmus. This is followed by a somewhat flattened portion, reaching a maximum at a point closely corresponding to the neutral point to phenolphthalein. After the maximum point the purity curve shows a sharp decrease. Exact figures for points of the purity curve are:

Initial purity	82.30
Maximum increase	2.87
Mechanical increase	0.58
Increase at litmus neutrality	1.0

Six of the series included in the average were on juices from cane that had deteriorated because of delayed harvesting. On account of the tendency of such juices to give a comparatively small increase in purity till after the neutral point to litmus is passed the figure for increase in purity at this point is probably somewhat lower than if sound juices only had been studied. For further information on this point, data for sound and deteriorated juices in Table VI have been averaged separately. The last item in the tabulation is a juice of the second class, failing to give a good increase in purity on clarification. With this item included the increase in purity in the deteriorated juices at litmus neutrality is 45% of the increase at the corresponding point in the sound juices. With this item excluded the ratio is 55%.

Table VI is a comparison of increases in purity at the neutral points of litmus and phenolphthalein. All series in which both points are available are included.

TABLE VI

Juice From Sound Cane

Cane	Mixed Juice Purity	Increase in Purity at Neutral Point to Litmus	Increase in Purity at Neutral Point to Phenolpthalein
H 5001, Experiment Station..	84.28	0.56	1.57
H 5001, Experiment Station..	88.12	1.46	3.02
H 5001, Experiment Station..	83.43	1.31	3.73
Y. C., Aiea	83.2	1.10	2.6
H 109, Experiment Station...	83.9	1.6	2.6
H 109, Aiea	82.24	0.64	3.0
Average	84.36	1.11	2.75

Juice From Deteriorated Cane

Lahaina, Aiea	75.49	0.48	3.11
D 1135, Waipahu	76.82	0.16	2.22
Lahaina, Aiea	75.48	1.22	2.96
D 1135, Waipahu	78.35	0.12	2.53
Lahaina, Aiea	75.52	1.07	4.34
Y. C., Waimanalo	74.07	−0.07	0.53
Average	75.9	0.50	2.62

It will be noted that in juices from sound cane the increase in purity at litmus neutrality was 40% of the increase at phenolphthalein neutrality. In juices from deteriorated cane it was 19%. The increase in purity, shown in the last column, was not in all cases the maximum.

The lime salts curve in Figure 5 shows a gradual increase to a point about midway between litmus and phenolphthalein neutrality. Beyond this point the increase is more pronounced. At phenolphthalein neutrality, lime salts are approximately three times the original amount.

As previously noted the increase in apparent purity is due principally to the removal of impurities, but is also due to some extent, particularly in the more alkaline juices, to the change in the ratio of polariation to sucrose. Gravity purities are not available for a sufficient number of series to plot a gravity purity curve in Figure 5 for comparison with the apparent purity. The following figures, however, are the averages of six clarification series in which both gravity and apparent purities are available.

Reaction to litmus	$\overline{.010}$	.002	.004	.008	.012	.015	.019
Gravity Purity	82.30	83.15	83.65	84.45	84.97	84.55	84.55
Apparent Purity	81.27	82.19	82.77	83.64	84.30	84.08	84.31
Difference	1.03	.96	.88	.81	.67	.47	.24

Over 90% of the increase in purity indicated by the apparent purity figures is confirmed by figures for gravity purity till .008 litmus alkalinity is reached. From .008 to .012 alkalinity some 80% of the increase in apparent purity is confirmed. At higher alkalinities differences between apparent and gravity purities rapidly decrease.

Litmus and phenolphthalein give entirely dissimilar indications, not only with respect to the neutral point, but in the relative results obtained on titrating. The curve for the relation of litmus to phenolphthalein reaction in Figure 5 has been plotted not so much in an attempt to establish a definite relation between them as to remove some of the confusion that exists as to the indications given by the two indicators when used in cane juice. The curve shows juice neutral to litmus to have an acidity of .047 to phenolphthalein. In juice neutral to phenolphthalein, however, an alkalinity of but slightly over .015 to litmus is shown. Approximately the same ratio of three to one holds good from litmus neutrality to the acidity of the original juice. The individual points for juices of the first class lay close to the curve, indicating that it may be taken as fairly representative of this relation in such juices. With juices of the class that do not clarify

satisfactorily a different relation exists, particularly in the region between the neutral points of the two indicators.

JUICES THAT DO NOT CLARIFY WELL.

We include in this class juices that on clarification will not give a large increase in purity and that will not settle in a reasonable time, leaving a clear solution. The only available clarification series that is at all complete on a juice of this class, is on Yellow Caledonia juice from Waimanalo plantation. All members of the series settled poorly and the maximum increase in purity was small. Data for the series are in Table VII.

TABLE VII

Treatment	Apparent Purity	Reaction Litmus	Reaction Phenol.	% P_2O_5
Mixed Juice	74.07	.012 acid	.083 acid	.029
Filtered Juice	74.65	.012 "	.083 "	....
3 ccs. Lime	74.00	Neutral	.048 "	.023
6 " "	74.83	.020 alk.	.038 "	.007
9 " "	74.74	.030 "	.018 "	.006
12 " "	74.23	.040 "	.012 "	.006
15 " "	74.60	.050 "	.006 "	.005
18 " "	74.74	.055 "	.002 "	.006
21 " "	74.60	.060 "	Neutral	.005

This juice differed from juices of the first class, not only in settling and size of the increase in purity, but also in the relation of phenolphthalein and litmus reaction, and in the lime requirement. From the acidity of the mixed juice to the neutral point to litmus the relation of phenolphthalein and litmus reaction agrees approximately with the curve in Figure 5. At neutrality to phenolphthalein, however, the alkalinity to litmus is .060 instead of close to .015, the figure indicated by this curve. Compared with juices of the class that clarify satisfactorily, the amount of lime required to reach the neutral point to litmus is about what would be expected. Between litmus and phenolphthalein neutrality a given amount of lime caused about the expected change in reaction to phenolphthalein, but some four times the change in litmus reaction that would be inferred from previous series. The maximum increase in purity was secured with 6 cc. of lime per liter. The reaction at this point was .020 alkalinity to litmus and .038 acidity to phenolphthalein. The litmus reaction of the point of maximum increase in purity was in fair agreement with that for the point of maximum increase in series on the other class of juices. Phenolphthalein reaction at this point and the amount of lime required to reach it do not, however, agree at all with previous results. The maximum increase in purity, 0.76, is but 0.18 higher than the increase obtained by filtration alone. There was a decrease in purity at the neutral point to litmus. In the more alkaline members of the series the purities were quite irregular.

While the data available for this class of juice do not go far toward defining either the size of the possible increase in purity or the reaction at which

the maximum can be obtained, considerable data are available pointing toward a close relation between low phosphoric acid content and the characteristics shown by this class of juices.

Attention was first directed to the phosphoric acid content while examining juices giving turbid settled juice and small increases in purity at Oahu Sugar Co. D 1135 juice that settled most unsatisfactorily, after the addition of di-sodium phosphate equivalent to 0.02% P_2O_5 and liming to the point where the P_2O_5 was precipitated, gave a clear, almost limpid settled juice. H 109 juice also giving trouble contained .015% P_2O_5. Increasing the P_2O_5 to .035% resulted in clear settled juices. Lahaina juice with .027% P_2O_5 was giving a fair, though not by any means clear, settled juice. Following this examination a soluble phosphate was used in the factory while these juices were handled and excellent settling was secured. Better settling was accompanied by a better increase in purity. It is probable that this was due to the fact that the clarification was conducted at a more alkaline reaction, rather than to actual precipitation of impurities by the phosphate added.

The Waimanalo sample which did not settle or give a good increase in purity (Table VII) contained .029% P_2O_5. On clarification this was reduced to .006% in the more alkaline members of the series. A sample of Yellow Caledonia juice from Waialua (Table V and Figure 4) gave a clear settled juice and a fairly large increase in purity. This juice contained .074% P_2O_5. The P_2O_5 content was reduced at .010 litmus alkalinity to .005%. A sample of juice from Ewa gave an increase in purity of 2.8 and well settled juice. The P_2O_5 content was .034%. This was reduced to .004% in the more alkaline clarified juices.

Six samples of juice were clarified with 5 and 8 cc. of lime, with the object of further studying the phosphate content. The data are in Table VIII.

TABLE VIII

Sample	Mixed Juice				Clarified Juice 5 ccs. Lime per Liter				Clarified Juice 8 ccs. Lime per Liter			
	Apparent Purity	Reaction *	% CaO	% P_2O_5	Purity Increase	Reaction *	% CaO	% P_2O_5	Purity Increase	Reaction *	% CaO	% P_2O_5
1	91.23	.014 acid	.013	.099	1.90	.006 alk.	.017	.010	2.58	.012 alk.	.038	.011
2	92.38	.010 "	.013	.092	2.83	.006 "	.019	.013	3.12	.012 "	.035	.010
3	91.37	.010 "	.013	.102	1.45	.006 "	.018	.010	2.66	.012 "	.033	.007
4	92.11	.010 "	...	.038	.89	.014 "	...	.007	2.56	.018 "	...	.007
5	90.9	.010 "	.014	.016	1.1	.014 "	...	...	1.1	.018 "	.105	.010
6	86.8	.008 "	.017	.011	–0.4	.024 "	.077	.011	–0.1	.028 "	.116	.010

* Referred to litmus.

Samples Nos. 1, 2, and 3 are, respectively: Lahaina, H 109, and D 1135 cane from the Experiment Station plots in Honolulu. The P_2O_5 content is high and does not differ materially in the different varieties. They gave well settled

juices and satisfactory increases in purity on clarification. Samples No. 4 was Lahaina juice from Field 25, Oahu Sugar Co. This sample, containing .038% P_2O_5 gave well settled clarified juices and a good increase in purity. Samples 5 and 6 are H 109 juices from Experiment 6, Field 45, Oahu Sugar Co. No. 6 is from the check plots receiving no phosphate fertilization, while No. 5 is from the "C" plots, to which 90 pounds P_2O_5 in the form of superphosphate, were used per acre. Sample No. 5, with .011% P_2O_5, gave extremely poor results on clarification. A decrease in purity resulted and the settled juices were very turbid. Sample No. 6, with .016% P_2O_5, gave slightly better results. A 1.1 increase in purity was secured; the settling, however, was but little better than in No. 5.

The large increase in alkalinity to litmus caused by a comparatively small amount of lime in low phosphate juices is evident in this tabulation. The clarified juices of samples Nos. 5 and 6 were also high in lime salts.

In connection with the phosphate content shown in Table VIII, we would note that the Experiment Station plots are high in available P_2O_5.[5] It is probable that the juices previously examined from these plots had a P_2O_5 content similar to samples 1, 2, and 3. Field 45 is low in available P_2O_5 and responds to phosphate fertilization. Such fertilization evidently improved the juice from the C plots, but did not raise the P_2O_5 content sufficiently to class it with juices giving satisfactory clarification.

In this investigation all juices, with but one or two exceptions, that have given clear settled juices have given increases in purity of 2.5 or more when at all complete clarification series have been run. On the contrary, juices that have not given clear settled solutions have in no case given large increases in purity. All of the latter class have been low in P_2O_5 content.

The action of the phosphoric acid in clearing up the juice appears to be mechanical, the heavy precipitate of calcium phosphate carrying down the coagulated colloids. Though definite conclusions as to settling under factory conditions can hardly be drawn from laboratory experiments. According to all present information we are inclined to place the dividing line between the two classes of juice at from .030 to .035 parts of P_2O_5 per 100 parts of juice.

There is little available information as to the phosphate content of Hawaiian juices. Judging from observation of the clarification at the different factories, however, it seems probable that a very large proportion are of the class that clarify well.

Practical Considerations.

With juices of the class that clarify well a decided improvement in the increase in purity is secured by carrying the clarification at a more alkaline point than is the common practice. Clarification practice in Hawaiian factories varies to a considerable extent. There are still a few factories where the clarified juice is acid to litmus. In a few, very alkaline clarification has been adopted. In most of the factories, however, the clarification is at close to the neutral point to litmus, and a decided prejudice exists against passing this point to any extent.

[5] Record, Vol. 26, No. 1.

In juices of the first class the maximum increase in both apparent and gravity purity has been obtained at the neutral point to phenolphthalein, the increase in apparent purity at this point being anywhere from two to four times the increase at the neutral point to litmus. Difficulties in settling need not be anticipated even when going as far as phenolphthalein neutrality, except in cases where settling and filter press capacity are very limited. While the volume of the settlings increased apparently more than in proportion to the increased amount of impurities precipitated at the higher alkalinities, in none of the juices investigated have increased amounts of lime caused the settled juices to be less clear, till the neutral point to phenolphthalein has been passed. After this point the settling was in a few cases unsatisfactory. Lime salts were usually three times the original amount at the neutral point to phenolphthalein. The effect of this on incrustation of heating surfaces cannot be predicted from present information. Glucose was attacked by lime to some extent before reaching the neutral point to phenolphthalein. Whether or not this was to an extent that would cause difficulties with the low grades also cannot be predicted from laboratory results. Whether or not, then, it is practicable to carry the liming to a point where the clarified juices are neutral to phenolphthalein and so secure the whole of the possible increase in purity can only be determined by carefully controlled factory practice.

It will be noted, however, that at a point midway between litmus and phenolphthalein neutrality, corresponding to about .008 litmus alkalinity, a very large part of the possible increase in gravity purity was secured. At this point lime salts have increased but slightly and glucose has not been attacked to any material extent. While it may not be practicable to carry the clarification at the neutral point to phenolphthalein, carrying it at this point appears feasible. Both analytical data and results secured in factories now using an alkaline clarification indicate that complications are improbable in carrying the clarification at this point.

Unfortunately this point is sufficiently alkaline to litmus so that the color change of litmus paper loses much of its value for definitely locating it. The point is acid to phenolphthalein, so this indicator does not show any color reaction and cannot be used directly. It can, however, be definitely located by titrating the clarified juice. At very close to this point the clarified juice usually shows the change from a reddish yellow to a clear light yellow color that is sometimes termed "over-liming." This change usually occurred just before this point was reached. We have also found that if the cold juice is limed till neutral to phenolphthalein, after heating the clarified juice will be at close to the desired reaction.

The point we have been discussing is in quite close agreement with the point referred to several times, though not directly recommended, by Deerr in the revised edition of Cane Sugar. This is "an acidity of 0.5 cc. normal per 100 cc. referred to phenolphthalein as an indicator." It is not at all in agreement with the suggestion of Prinzen Geerligs, that lime be added till no further precipitate is formed on adding calcium sucrate to the clarified juice. We have found that calcium sucrate forms a precipitate in hot clarified juice till a moderate alkalinity to phenolphthalein is reached. A reaction as alkaline as this is

undesirable, for at such a point we have usually found decreases from the maximum purity, and difficulties due to the use of an excessive amount of lime may be anticipated.

The above recommendations are for juices of the class that clarify satisfactorily. Present information does not permit us to specify as closely the point to which liming should be carried in juices of the class that do not clarify satisfactorily. They should be alkaline to litmus to avoid inversion. There are indications, however, that adding lime till the clarified juice is neutral to phenolphthalein, or even midway between litmus and phenolphthalein neutrality, is undesirable. Poor settling in these juices can be corrected and clear settled juice secured by adding a soluble phosphate in such proportion that the P_2O_5 content is brought up to from .03 to .035%. When this is done lime should be added till the clarified juices have an alkalinity to litmus of approximately .008, so that the maximum precipitation of P_2O_5 takes place. If the clarification is properaly conducted all the P_2O_5 that has been added is recovered in the press cake in the form of a finely divided precipitate, fairly available as plant food. As the fertilizer value of the phosphate used is thus realized, a deduction of this value may be made in estimating the cost of securing clear, well settled juice when working juices of the class that do not clarify satisfactorily.

This investigation of clarification is being continued and no doubt further information on the questions already taken up will be obtained.

Sugar Prices

96° Centrifugals for the Period

December 16, 1921, to March 15, 1922.

Date	Per Pound	Per Ton	Remarks
Dec. 16, 1921	3.765 ¢	$75.30	Old and new Cubas.
" 20..........	3.735	74.70	Delayed sale, old crop Cubas.
" 21..........	3.73	74.60	Made up, Philippines 3.60, old crop Cubas 3.86.
" 22..........	3.86	77.20	Old Cubas.
" 23..........	3.6367	72.734	Spot Cubas 3.86, for new shipment 3.51 and 3.54.
" 24..........	3.86	77.20	Spot old Cubas.
" 27..........	3.64	72.80	Spot Cubas Committee 3.86, Nearby new 3.42.
" 28..........	3.61	72.20	Old spot 3.86, new 3.36.
" 29..........	3.73	74.60	Spot Cubas.
Jan. 3, 1922	3.61	72.20	Spot Cubas.
" 4..........	3.61	72.20	Spot old Cubas.
" 6..........	3.545	70.90	Non-controlled 3.48, Committee 3.61.
" 7..........	3.61	72.20	Committee old Cubas.
" 9..........	3.575	71.50	Average, Committee old Cubas 3.61, old crop 3.54.
" 10..........	3.575	71.50	Average, Committee old Cubas 3.61, old crop 3.54.
" 11..........	3.575	71.50	Uncontrolled old Cubas 3.54, Committee 3.61.
" 12..........	3.61	72.20	Committee old Cubas.
" 13..........	3.575	71.50	Average, Porto Ricos 3.54, Committee old Cubas 3.61.
" 14..........	3.61	72.20	Committee old Cubas.
" 16..........	3.575	71.50	Uncontrolled old Cubas 3.61, Philippines 3.54.
" 17..........	3.61	72.20	Old Cubas.
" 19..........	3.6917	73.834	Committee old Cubas 3.61, old Cubas 3.73, Philippines 3.735.
" 20..........	3.7625	75.25	Philippines 3.735, old Cubas 3.79.
" 21..........	3.86	77.20	Old Cubas.
" 25..........	3.81	76.20	Porto Ricos 3.76 and 3.86.
" 26..........	3.76	75.20	Porto Ricos.
" 27..........	3.70	74.00	Average 3.73, old Cubas 3.67.
" 31..........	3.73	74.60	Old Cubas.
Feb. 1..........	3.61	72.20	Porto Ricos.
" 2..........	3.64	72.80	Old new Cubas 3.67, Porto Ricos 3.61.
" 3..........	3.67	73.40	Old Cubas.
" 9..........	3.575	71.50	Old Cubas 3.61, Porto Ricos 3.54.
" 10..........	3.605	72.10	Cubas 3.67, Porto Ricos 3.54.
" 15..........	3.605	72.10	Old Cubas 3.67, Porto Ricos 3.54.
" 16..........	3.635	72.70	New Cubas 3.73, Porto Ricos 3.54.
" 17..........	3.79	75.80	Old Cubas 3.79, new Cubas 3.79.
" 18..........	3.86	77.20	New Cubas.
" 20..........	3.86	77.20	Old and new Cubas.
" 24..........	3.70	74.00	Old and new Cubas.
" 27..........	3.635	72.70	New Cubas 3.73, Porto Ricos 3.54.
Mar. 1..........	3.70	74.00	New Cubas 3.79, Porto Ricos 3.61.
" 2..........	3.69	73.80	New Cubas 3.79, Porto Ricos 3.61 and 3.67.
" 3..........	3.67	73.40	New Cubas 3.73, Porto Ricos 3.61.
" 4..........	3.73	74.60	Old Cubas.
" 6..........	3.79	75.80	New Cubas.
" 8..........	3.7833	75.666	New Cubas 3.79 and 3.86, Porto Ricos 3.70.
" 9..........	3.81	76.20	New Cubas 3.86, Philippines 3.76.
" 10..........	3.89	77.80	New Cubas 3.89 and 3.92, Porto Ricos 3.86.
" 11..........	3.86	77.20	Philippines.
" 13..........	3.92	78.40	Old Cubas.
" 14..........	3.89	77.80	New Cubas 3.86, old and new Cubas 3.92.

THE HAWAIIAN PLANTERS' RECORD

Volume XXVI. JULY, 1922 Number 3

A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

The Growth of the Sugar Cane Plant

Sugar planters have always recognized climate as a definite asset and have known that the different seasons of the year vary widely in their effects upon cane growth. Recently attempts have been made to place mathematical ratings on the different months, in order to show their relative values from a cane or sugar production standpoint.

Tables were compiled two years ago by J. A. Verret and W. P. Alexander, based on cane growth measurements covering several years at Ewa Plantation. Parallel columns showed the elongation of the stalk in inches as measured each month, and alongside of this a percentage figure denoted what part of the total crop this stalk growth represented. For instance, in short ratoon cane of fourteen months growth, we find these values:

	Increased length of well developed stalk in inches	Part of crop represented in each month's cane measurements
March	8.5	5.8%
April	9.0	6.1
May	11.5	7.8
June	13.9	9.5
July	13.8	9.4
August	17.0	11.6
September	15.8	10.7
October	15.9	10.8
November	13.5	9.2
December	8.3	5.7
January	6.0	4.1
February	4.6	3.1
March	4.5	3.1
April	4.6	3.1

At the suggestion of Mr. Alexander, we are now considering additional tables which will take due account of how and when the weather of a given month is registered in stalk growth. The part of the cane stalk that is in

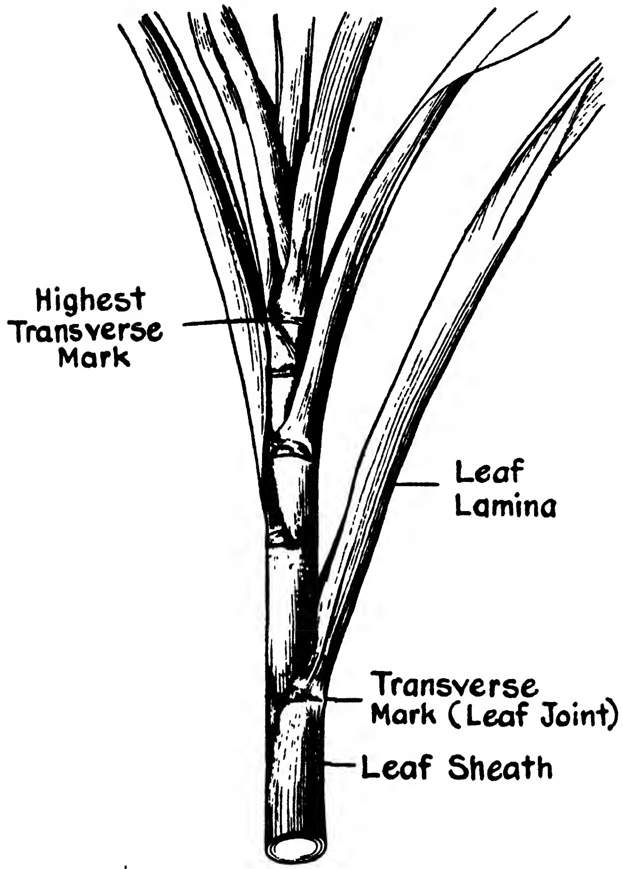
process of elongation is the immature portion that is encased in the growing top. Such growth as is caused by the weather of June, for instance, is not exhibited as fully formed cane stalk until several weeks later. We are inclined to believe that the maximum growth measured in August was actually caused in June, or thereabouts. The high point in cane growth under Oahu conditions would then coincide more nearly with the season of greatest daylight instead of the period of highest mean temperatures. The lowest rate of growth would be expected in December. Cane planters are frequently impressed by the fine appearance of cane in September, when new, long joints appear. This growth took place, probably, in July and becomes visible two months later when the tightly encased leaf-sheaths loosen and fall apart. In September the growth is checked somewhat abruptly, as a result of which, tassels are formed at the growing tip. These tassels make their appearance fully developed in November.

In studying this question a great amount of help can be had from a paper by C. A. Barber, for he throws much light on the subject by recording the observations of others who give us new and definite information on the process of cane growth. The dissection of cane tops in connection with the information presented by Mr. Barber serves to confirm the observations that have led Mr. Alexander to suggest the construction of additional tables that will show for each month the cane growth brought about by the climatic environment (temperature and daylight hours) of that particular period. We read from Mr. Barber's paper: *

One of the greatest difficulties in measuring growing canes is due to the fact that the portion in actual elongation is permanently enswathed in a mass of leaves which cannot be removed without disturbing the growth. Observation of the ends of these leaves cannot be used in measurement because of the constant variation in length of successive leaves during the growing period. It becomes necessary to find some definite external point on the shoot which bears a constant relation to the growing point of the stem within. Kamerling set himself to find such a point. His object was to study the rate of growth in different fields and varieties and to replace the general terms in use, such as "rapid," "slow," "moderately slow," and so on, by exact measurements, at the same time pointing out the importance of such work for the factory. By determining the rate of growth under certain well defined conditions, he claimed that we should be in a position not only to decide the fitness of a variety for its locality, but also to fix on general measures whereby unsatisfactory growth might be remedied. He first of all found that there is a sequence of growth in length in the lamina, leaf sheath and stem of a very definite character. The lamina first grows in length, rapidly unfolds itself and ceases from any further increase; as soon as this is completed, the energy of growth is transferred to the sheath. It quickly elongates and pushes the lamina into the air and light, and in its turn ceases from further growth in length. Lastly, when the leaf sheath has finished growing, the stem internodes, hitherto merely a series of flat, superposed discs, suddenly elongate by the expansion of their cells and cease to grow in length after a very short time. The sheaths thus complete their growth in length before the internodes commence to elongate, and their further apparent growth is due to the increase in length of the internodes to which they are attached. In the young shoot each leaf sheath is entirely covered by the one outside it, while it is yet undeveloped, but the moment when it emerges from this protection Kamerling shows to coincide with its cessation of growth. The tops of two successive sheaths are now close together, and any

* Memoirs of the Department of Agriculture in India, Botanical Series, Vol. X, page 156.

further separation is due to extension of the stem which at this period commences to elongate. The top of the leaf sheath is the place where it joins the lamina, and Kamerling selected this point, which he calls the "blad-gewricht" (leaf joint), as the one by the observation of which he could indirectly observe the growth in length of young joints of the stem apex (see Figure). This demonstration of Kamerling's has been found to be justified, *on the assumption that all of the mature leaf sheaths are of equal length.* He measured a series of leaf sheaths in different canes and soon found that, while the differences in their length in fully grown parts of the cane plant were very small, both at the beginning and end of the vegetative season the leaf sheaths were of different sizes. The first sheaths are very small, these successively increase in length until they reach a fairly uniform maximum, and this is maintained during active growth. Towards the end of the season, however, the sheaths again diminish in length. He made a distinction between the actual growth of the young internodes and their "apparent" growth, as judged by the observation of the leaf joint, and showed that, while the difference between the actual and apparent growth is small during the period of full growth of the cane plant, it is large at the beginning and end of the season. Kamerling then tried a method of measuring the growth of the stem directly, by removing the leafy mass around the actively elongating portion, marking it and covering it with tin foil, and measuring it again after twenty-four hours. The results agreed with those already obtained, showed that the region of elongation was confined to few joints, and that, in these the top of each joint ceased growing first and the lower part continued elongating after the upper had ceased to alter, that is, that the region of most active growth in length in each joint was basipetal. But such harsh treatment of the young growing parts soon introduced irregularities in development, and Kamerling's main results depended on the indirect method mentioned above.



To Kuijper belongs the credit of overcoming once and for all these difficulties. After trying various methods, he hit upon the ingenious plan of piercing the whole growing shoot with a darning needle (finer instruments encountered too much resistance), starting with a full-grown leaf sheath on the outside, which showed no further movement, and working upwards. A series of holes were thus made through the whole mass of growing parts, and, as growth took place, these holes were pushed up in various degrees in the different organs inside. After a period of six days the relative position of the holes was studied, and their change in position gave an accurate measure of the growth which had taken place in each organ. By multiplication of the initial holes at distances of about one centimetre up the outer leaf sheath, he was able to state definitely in what part of each organ growth was most rapid, as all that remained to be done was to dissect

out the mass after a stated interval, lay out the parts, and measure the vertical distances between the holes. While this method was found to disturb the growth in very young parts, it fully justified its use, and the general results obtained by Kamerling were substantiated, but, by a series of *actual,* in place of *inferred,* measurements. The basi-petal tendency of the zone of most active growth in each internode was confirmed, and it was found that the leaf sheath and lamina behaved in a similar manner. Kuijper's work was, in the main, instituted for a study of certain diseases of the shoot, which appeared to depend on the relative growth of the young parts, and the previous work of Kamerling did not give the accurate figures required for this. He fully endorsed the selection of the upper most visible leaf joint for measurement in stem growth, safeguarding it, as was done by Kamerling, at the beginning and end of the season. We are indebted to him for the first clear demonstration of what goes on inside the growing portion of the cane shoot.

Yield of Sugar in the Territory of Hawaii for Crop of 1921.

	Acres	Tons Sugar Harvested	Lbs. Sugar per Acre	Tons Sugar per Acre
Total yield	119,854.77	564,562.2505	9,420	4.710
Irrigated plantations	63,686.01	350,199.2360	10,998	5.499
Unirrigated plantations..	56,168.76	214,363.0145	7,632	3.816
Hawaii	54,303.76	208,522.8470	7,680	3.840
Oahu	23,142.08	130,972.3780	11,318	5.659
Kauai	23,120.93	108,037.5850	9,346	4.673
Maui	19,288.00	117,029.4405	12,134	6.067

Mites and Other Organisms in Their Possible Relation to Sugar Cane Root-rot in Hawaii.

By C. E. Pemberton.

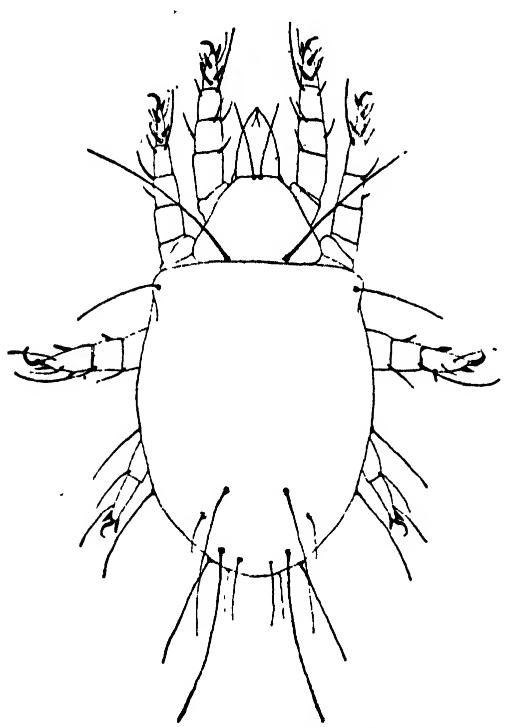
During recent root investigations in diseased cane at Grove Farm and Honokaa plantations, Dr. L. O. Kunkel observed extensive injury to live roots of a type which appeared to be entirely apart from fungus infection. Roots were badly perforated with holes which he suspected were made by something in the nature of a worm. The holes were so numerous and the injured roots so generally distributed in the diseased areas that he concluded that the "worm injury" could alone readily account for and be the "primary cause" of Root-rot in these fields. Dr. Kunkel's remarks,* in part, respecting this injury, were as follows:

> The dead and dying roots of the ratoon cane are infected with several different undetermined fungi. There can be no doubt but that these organisms are capable of causing Root-rot after they have once entered the tissues. Whether or not they are able to attack sound roots is not known. They seem to enter the roots through what appear to be *small worm-holes*. Worms were not actually found in the roots. The injury is similar to that which has been observed at Honokaa, and which is suspected of bringing about Root-rot troubles there. In some of your ratoon fields, for example Field 15, practically every root is more or less worm eaten. Through the wounds made by the worms, various parasites (fungi) enter and destroy the tissues. It is our opinion that the worm-injury is the primary cause of Root-rot in these fields. For some reason the worms do very little damage to the roots of plant cane.

With the object of locating if possible the insect, worm, or other organism, which might be making the many holes in the roots which Dr. Kunkel recorded, a careful examination was made among roots in poorly-growing ratoon cane at Kukuihaele and in plant and ratoon cane at Honokaa. Such root conditions as

* Letter to E. H. W. Broadbent, Manager Grove Farm Plantation, Lihue, Kauai, dated April 5, 1922.

Dr. Kunkel described were immediately found. Holes of varying shape and size were exceedingly abundant both in tender, growing roots, all the way from the tip to the base; scattered through most of the dead roots; and particularly common in the small roots just starting. Frequently entire ends of a young vigorous root were completely hollowed out. The root-injury can be found both in young and mature plant cane, and in ratoons. The holes in the roots vary generally from one-half to one millimeter (1/50th to 1/25th in.) in diameter, are more or less circular, may be shallow or penetrate to the central cylinder of the root or sometimes go clear through. They frequently occur at the very growing tip. Similar root-injury was commonly found in Lahaina and H 109 cane on Honolulu Plantation at Puuloa and in the same varieties at Ewa Plantation. Such injury can seriously handicap the growth of the cane, when the majority of the roots are punctured, as is frequently the case.



A species of mite (*Rhizoglyphus rhizophagus*), highly magnified, which is related to one found in Hawaiian soils. (Reproduced from "A Treatise on the Acarina, or Mites," by Nathan Banks of the Smithsonian Institution.)

At Honokaa, a minute brownish mite was several times actually found in the freshly-made holes in tender, growing roots, and further search revealed it present wherever the typical root-injury occurred. Owing to its minute size and brownish color, it was at first easily overlooked. One cane eye just beneath the surface of the ground was found under which a number of these mites were clustered. Considerable of the rind-tissue, where they were gathered, had been eaten. It did not appear to be bud-moth work and distinctly not wire-worm injury. Similar mites were also found present among the roots of the injured cane at Puuloa and at Ewa.

It is yet too early to state definitely the part played by mites and other animal organisms in the formation of these root-holes. The injury has most likely been going on for a long time. The clean-cut holes and gashes in the roots are of such a definite character and so similar in all cane examined, that it is probable that only one type of organism is particularly responsible for most of the damage. Several minor factors may also contribute to the injury, however, for newly budding roots at or very close to the surface are sometimes found with holes and cuts in them that are larger than the characteristic perforations in an average root. The fauna of our cane soils, though very inconspicuous in general, is fairly rich. Among the possible cane-root feeders may be mentioned the numerous nematodes, whose relations to the cane are mostly unknown; Acari, or mites, in

abundance; ants of several species, present in enormous numbers and penetrating wherever cane-roots will go; and active Crustaceans, living mostly on organic matter. A minute snail has also fallen under suspicion. One mite, as discussed above, has already been seen at work. Its real importance has yet to be determined. F. Muir and O. H. Swezey have just found that one of the Crustaceans, a common sow-bug or wood-louse, will eat holes in cane-roots when placed with them in confinement, and two of the known nematodes have long been recorded as cane-root feeders, though they do not cause such holes in the cane-roots as discussed herein. It is quite possible that ants may bite into tender cane-roots when encountered during their intricate ramifications in the soil, in, under and about the cane-stools. It would be wholly within their general habits though their actual dependence on roots for food is not likely.

The mites conspicuously present among the injured roots will need careful study. Their general distribution in cane from the top to the bottom of the stools, everywhere accompanying the injury, throws much suspicion upon them. Certain mites have had a black history. Many are known to be destructive to plants and the food of animals and man and some are particularly injurious to the roots of plants. The family *Tyroglyphidae* contains species of economic importance. They particularly attack stored foods and the bulbs and roots of plants. Most of them feed upon vegetable matter. Nathan Banks, the foremost American authority on the Acarina, or mites, states that the *Tyroglyphidae* feed upon "cheese, flour, hams, dried meats, hair in furniture, cereals, many drugs, dried fruits, seeds of all kinds, bulbs, feathers, hay and entomological specimens." He states that in Europe one species lives in mushrooms and spreads disease that causes the decay of the pileus (the upper part). An American species of the same family is also said to be highly destructive to growing mushrooms. The bulb mite *Rhizoglyphus hyacinthi* is recognized as an important bulb-pest and is said by Banks to be "responsible for an enormous amount of damage," and that "in Europe it has lately been proved that this, or an allied species, does great damage to the roots of grape-vines." He further states that it can be controlled by the use of carbon-bisulphide injected into the soil above the infested roots. Other species of the same genus are injurious to the stems of carnations and the roots of asparagus.

The recognition of this extensive root-injury thus opens a new field for biologic investigation in the Hawaiian cane fields and promises to be an important one. The determination of the causes and the application of successful control methods to prevent such damage, may solve many so-called soil problems and explain the poor condition of much cane which often fails to respond to elaborate processes of cultivation and fertilization.

Fig Trees for Hawaiian Forests.

By H. L. Lyon

(Concluded from page 87.)

The Banyan

Among the fig trees already present in Hawaii, the banyan, *Ficus Bengalensis*, is easily the most striking novelty. It is a rapidly growing tree which quickly attains large dimensions. In its native haunts in India, single banyan trees are said to occupy more space than any other known tree. A specimen with a crown over 2,000 feet in circumference has been recorded and trees with crowns 300 to 500 feet in diameter are not uncommon. From a central trunk which attains large size, the banyan throws out massive horizontal branches which send down to the ground at intervals aerial roots which eventually become secondary trunks. In this manner the tree virtually walks over the landscape producing an enormous dome of dense foliage supported on numerous column-like trunks.

The banyan is a natural component of the forests throughout India, extending down to sea level in the south and up to 4,000 feet elevation in the north. It can endure prolonged droughts and survive severe frosts, but under the first named condition it usually drops most of its leaves, and under the last named, it may lose all of them. The tree is notoriously hardy, submitting indefinitely to the most severe mutilation. It is highly esteemed in all parts of India and is extensively planted for shade in villages and along roadsides. The leaves and young branches constitute a choice fodder for elephants and are much used for this purpose, the felling of a banyan being prohibited by law within a certain radius about the recognized camping grounds of elephant trains, in order to insure an adequate supply of fodder for the beasts.

The leaves of the banyan are large, ovate, or elliptic and rather thick and coarse. The fruits are pubescent, 1/2 to 3/4 inch in diameter and bright scarlet when ripe. In India these fruits are freely eaten by birds, bats and monkeys, and on occasion by human beings.

We have located sixty-seven fruiting specimens of the banyan in Honolulu and doubtless a careful search would reveal many more. All visitors to our city are much impressed by the splendid banyans in the grounds of the executive and judiciary buildings and all kamaainas are familiar with the magnificent specimen in the public square at Lahaina.

The foliage of the local trees is often covered with a black sooty-mold that grows on the excretion of a mealy bug which feeds on the leaves and young twigs. This same mealy bug injures the foliage and fruit of the cultivated fig, *Ficus carica,* and is the most serious pest attacking the leaves of the avocado. It also infests other economic plants. The Board of Commissioners of Agriculture and Forestry has recently undertaken to find and introduce into Hawaii

parasites and predators which will prey upon this troublesome insect. During the past few months, H. T. Osborn, who is doing the field work on this project, has sent over from Mexico several mealy-bug-destroying insects which promise to establish themselves here. It is to be expected, therefore, that within a few years the sooty-mold will be far less prevalent on our banyans than it is at the present time, due to the reduction of the mealy bug by its natural enemies.

Fig. 7. *Ficus Bengalensis*. The aerial root system of one of the big banyans in the grounds of the Executive building in Honolulu.

The banyan might easily be used to very good advantage in the protection of our old forests and in the creation of new forests on our watersheds. It should be of particular value as a component of the lower barrier forests. It produces all by itself an excellent cover which can successfully withstand heavy winds, floods and droughts as occasions demand. On steep slopes it would prove an effective soil binder, preventing land slides and gulching. The introduction of the wasp peculiar to *Ficus Bengalensis* has not been approved by the Board of Commissioners of Agriculture and Forestry.

The Chinese Banyan

The fig tree, *Ficus retusa*, which is locally known as the Chinese banyan, is a natural component of the vast forests of the sub-Himalayan tract in northern India and Burma, but it also extends through southern China, Siam, the Malay peninsula, and onto many of the islands of the Malay archipelago. The tree was undoubtedly introduced into Hawaii from China and consequently it became known as the Chinese banyan.

Fig. 8. *Ficus retusa.* A fine specimen of the Chinese banyan growing in the arboretum which surrounds the manager's house at Kukuihaele.

This tree is quite often planted in India for shade and ornament but it is not as popular for these purposes as are the true banyan, *Ficus Bengalensis,* and the Peepul tree, *Ficus religiosa.* In Java, however, *Ficus retusa* is a favorite tree for planting along roadsides and in public places where space is available. The Javanese often train and trim the crowns of trees of this and similar species into fantastic shapes. In the ancient town of Djogjakarta may be seen "Waringin" trees with crowns approximating in shape many of the well known geometrical figures, such as cubes, prisms, etc. *Ficus retusa* was one of the very first large growing trees to make its appearance on the island of Krakatau after the titanic volcanic eruption of 1883 had destroyed all of the vegetation on that island. Seeds of this tree were undoubtedly carried to the island by birds and the species is now represented in the new flora by several trees of large dimensions.

Fig. 9. *Ficus retusa.* An example of the non-banyanizing type. This makes an excellent shade tree for lawns and parks. The specimen here illustrated stands in Thomas Square.

The Chinese banyan, like the true banyan, is inclined to grow in the horizontal direction to a greater extent than it does in the vertical direction, but its crown often mounts to nearly or quite a hundred feet in height. If left to itself and given plenty of room it branches only a few feet above the ground and produces a compact crown of very pleasing shape. In habit it closely simulates the true banyan but is easily distinguished from the latter by its more numerous and much smaller leaves which have blades only two to four inches long as compared to the four to eight inch blades of the banyan leaves. Then the fruits of *Ficus retusa* are small, not exceeding 1/3 inch in diameter, while those of *Ficus Bengalensis* are 1/2 to 3/4 inch in diameter. There are several varieties of the Chinese banyan, some being given to the production of drop-roots to a much greater extent than others. There are varieties like the one in Thomas Square which never produce any drop-roots at all.

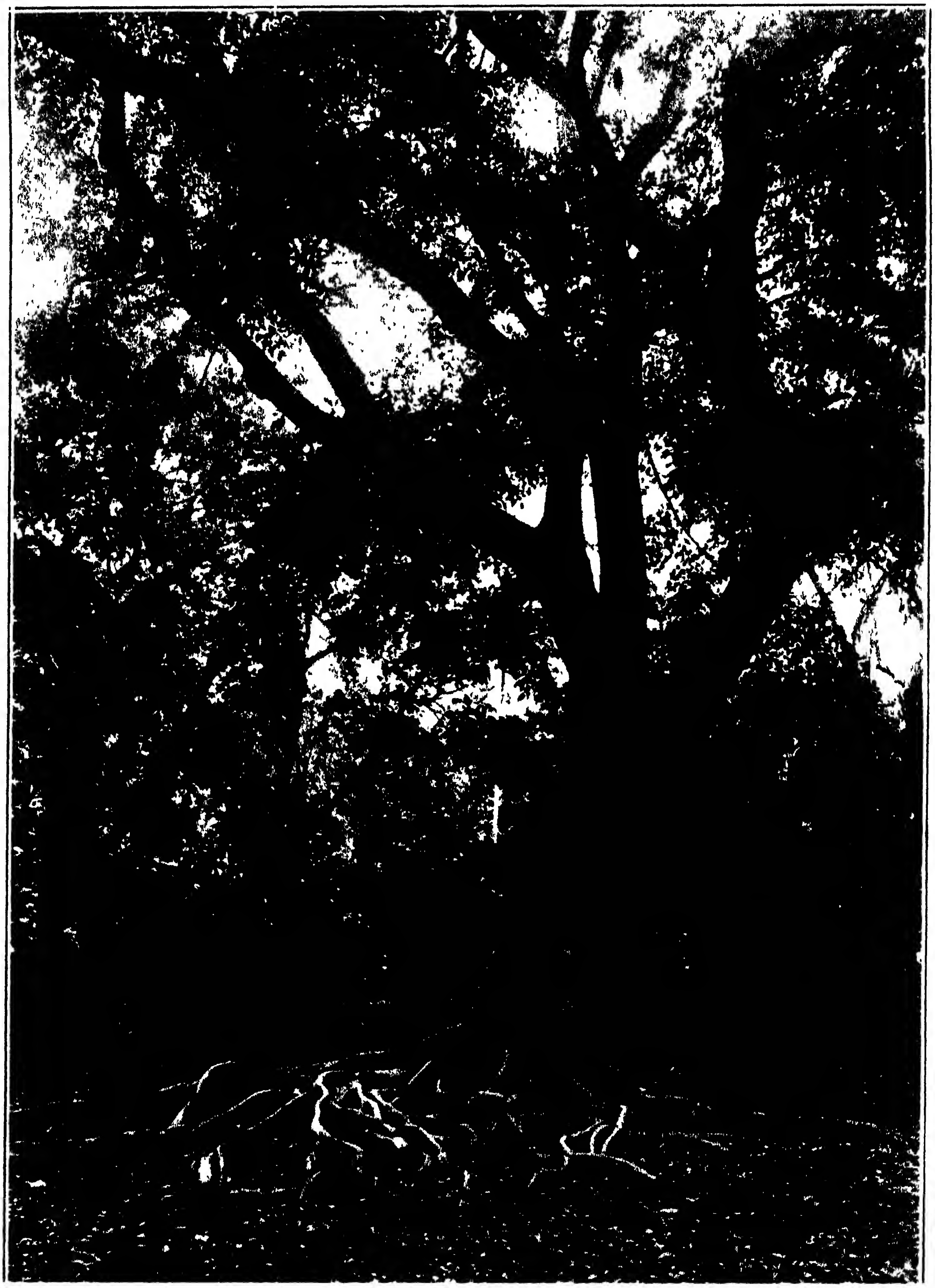


Fig. 10. *Ficus Benjamina comosa.* A very picturesque specimen of the weeping fig growing in Mrs. Foster's garden. It is quite evident that the soil beneath such trees cannot be removed to any extent by water erosion.

Ficus retusa holds second place among the fig trees as an ornamental tree in Honolulu, its representatives being slightly exceeded in numbers by those of *Ficus Bengalensis.* It is a much cleaner tree than the latter under our conditions, however, for it is less severely attacked by the mealy bugs and consequently its foliage is not so commonly disfigured with sooty-mold. There are many fine specimens of the Chinese banyan in Honolulu. Some of the most accessible ones are located in Ex-Governor Carter's grounds on Judd and Liliha streets, in Mrs. Foster's yard on Nuuanu between Vineyard and School streets, in the grounds of the Lunalilo Home, and in Thomas Square. The trees in the latter situation are of the type that do not banyanize or produce drop-roots. One of these trees is illustrated in Figure 9.

We are confident that *Ficus retusa* would prove a most useful tree in our forestry work. It will survive any mutilation short of absolute elimination. It is partial to moist situations and consequently should thrive in our rain forests. Of the many fig trees to be found in northern India it is said to be by far the most frost resistant and so we may reasonably expect that it can maintain itself up to an elevation of 6,000 feet or more, or as high as we shall wish to extend our forests.

Several attempts have been made to introduce into Hawaii the wasp peculiar to *Ficus retusa* but although insects in one or two consignments arrived in a living condition, they have failed to establish their race in local trees. There are many fruiting specimens of the Chinese banyan on the island of Hong Kong and the introduction of the wasp from that point should be accomplished without difficulty

The Weeping Fig

There is a handsome fig tree quite similar to, yet quite distinct from, the Chinese banyan which has almost exactly the same geographical range as the latter. To this tree the name *Ficus Benjamina* has been assigned. It so closely resembles some forms of *Ficus retusa* that it is quite generally confused with these and considered as belonging to the same species. In Java it shares with *Ficus retusa* the name Waringin and affords many subjects which are carved into geometrical forms as already described under the Chinese banyan.

Ficus Benjamina may be distinguished from *Ficus retusa* by its slightly longer and more pointed leaves which are placed at greater intervals on the twigs Its branches are more slender and their gracefully drooping habit has earned for the tree the name Weeping Fig. Like some varieties of the Chinese banyan, the Weeping Fig rarely if ever produces drop-roots, its crown being supported by a single trunk. There are two recognized varieties of the Weeping Fig which differ from each other only in the size of the fruit which they produce. The type of the species bears fruit only 1/3 inch in diameter while the variety *comosa* bears fruit 3/4 inch in diameter.

So far as we have been able to ascertain there are no specimens of *Ficus Benjamina* proper in Honolulu but there are four or five specimens of the variety *comosa*. Two of these are growing in Mrs. Foster's garden on Nuuanu, one in Mr. Albert Horner's yard on upper Nuuanu and one in the Spreckels tract in Punahou.

Ficus Benjamina var. *comosa* is a very fine forest tree and a choice ornamental. It could certainly be used to good advantage in the reforestation of our watersheds and should prove especially valuable in the middle and lower zones of our forests. The introduction of the wasp attached to the Weeping Fig has been approved by the Board of Commissioners of Agriculture and Forestry and it is hoped that a serious attempt may be made soon to establish it in our trees.

The Indiarubber Tree

The well known Indiarubber tree of horticulture, *Ficus elastica*, was at one time held to be a rubber-producer of great promise. It is by far the most important of the indigenous rubber trees of India and in the early days of the rubber industry was planted on a large scale both in India and Java. When the Para rubber tree, *Hevea Brasiliensis*, was introduced into the orient, however, it quickly demonstrated its superiority over *Ficus elastica* as a rubber producer and soon replaced the latter in all commercial plantings.

The Indiarubber tree is one of the most stately species of the genus *Ficus*. It is a rapid grower and attains gigantic size. Its main branches tend to approach the vertical rather than the horizontal direction, giving it an attitude of loftiness that is pleasing to look at and agreeable to the plants of lesser stature which must be associated with it in the forest.

There are many fine specimens of the Indiarubber tree to be found in Honolulu. Probably the largest tree now standing is in the grounds of the Queen Emma home on upper Nuuanu Avenue. Other trees of a goodly size may be seen in Washington Place, in Nuuanu Cemetery, and in the grounds of Lunalilo Home. The trunk of a huge tree at Koloa, Kauai, is the subject illustrated on the front cover of this number of the *Record*. The magnificent specimen in front of the Hilo hotel is known and admired by all who have occasion to stop there. Fourteen Indiarubber trees are standing in the grounds about the manager's house at Kukuihaele. The one shown in the photograph reproduced on the opposite page measured 110 feet over all in 1920. It is about thirty-five years old. There is a robust tree of *Ficus elastica* growing at about 2,500 feet elevation alongside of Mud Lane above Kukuihaele.

In its native land many wild specimens of the Indiarubber tree may be found which are over 200 feet tall and have a crown of 200 feet or more in diameter. The species is an inhabitant of the heavy forests and is most abundant in Assam and Upper Burma. It ascends to an altitude of 5,000 feet in the outer Himalayas.

Of the several species of Ficus which have already reached Hawaii from India, we are inclined to consider the Indiarubber tree the most desirable for forestry purposes. Attaining great height as it does it would give to our forest the vertical depth which is so essential and at the same time form a congenial

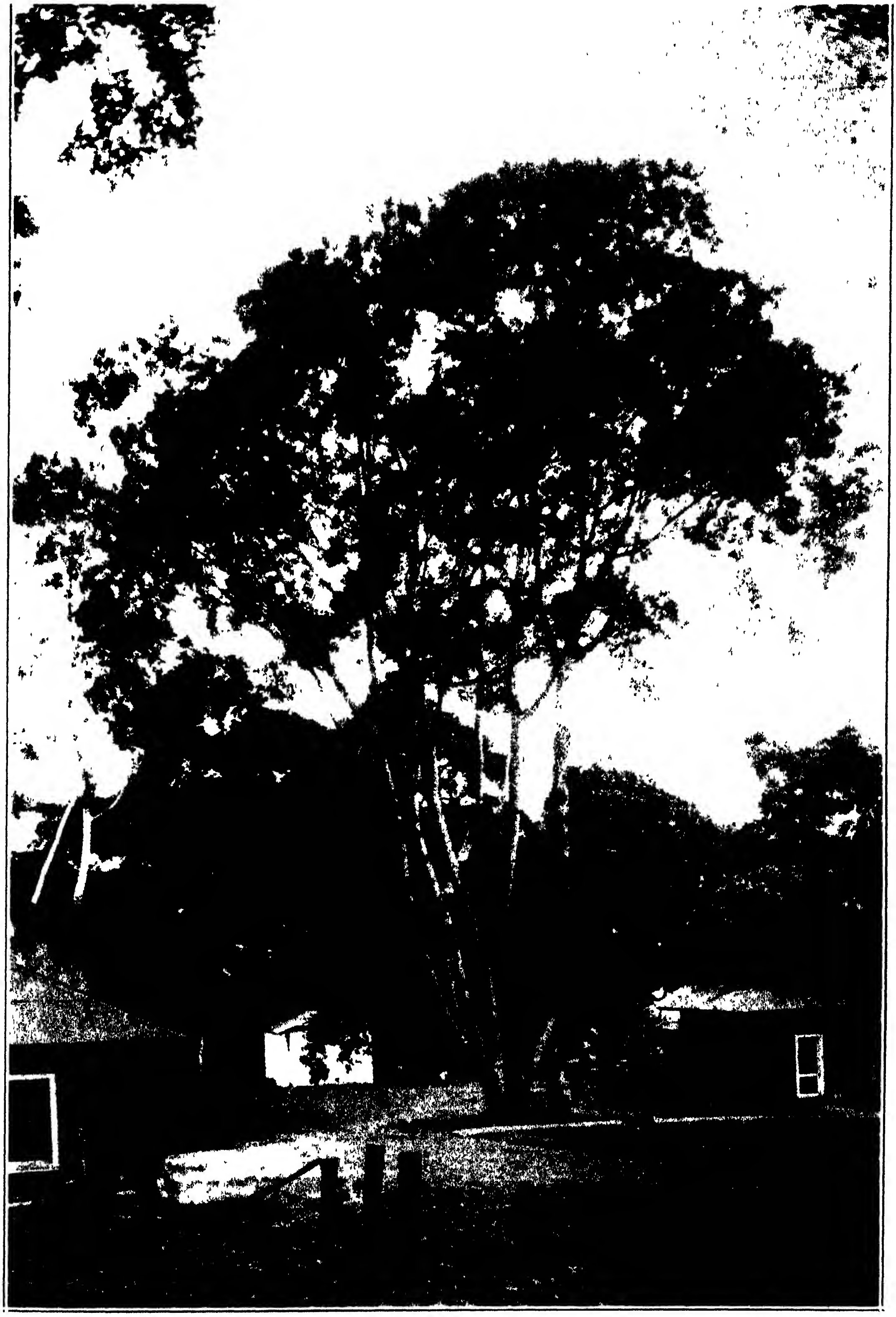


Fig. 11. *Ficus elastica.* This Indiarubber tree in the arboretum at Kukuihaele measured 110 feet over all in 1920. The tree to the left in the background is a banyan, *Ficus Bengalensis.*

associate for trees and shrubs of lesser stature. In this respect it ranks with the Moreton Bay fig and deserves equal attention. Unfortunately the wasp associated with *Ficus elastica* cannot be obtained at any point this side of India and the time required to travel through the intervening space is a serious obstacle to its successful introduction into Hawaii.* The desired result might be accomplished by transporting the fruits in a refrigerator, and the insects would surely come through on a small fruiting tree growing in a tub.

THE PEEPUL OR BO TREE.

The Bodhidruma* at Budh Gaya under which Sramana Gautama meditated and, receiving enlightenment, became Buddha, was named, some 2300 years later, *Ficus religiosa* by Linnaeus. Trees of this species have ever been held most sacred by the Buddhists, while the Hindus have strong religious scruples against injuring them in any way. Seedlings have always been allowed to grow and flourish wherever they chanced to start, and so the tree is often found in inappropriate situations. This tree is probably best known by the Hindi name Pipal or Peepul, but in Ceylon it is more commonly called the Bo tree.

Fig. 12. *Ficus religiosa.* One of the Peepul trees that may be seen in the Moanalua gardens.

It is claimed that the Bo tree in the ruins of Anuradhapura, near Kandy in Ceylon, is the oldest tree in the world. We are told that this tree has grown from a branch of the very tree under which Buddha sat, the branch having been planted during the year 288 B. C. As a matter of fact, it is but a young tree when its age is compared with that of some of the giant redwoods of California.

* Bodhidruma = Tree of Intelligence.

Ficus religiosa is indigenous to the sub-Himalayan tract of northern India, but it has been extensively planted in all parts of the Orient for over twenty centuries and now is to be found running wild throughout India, Burma, Siam and the Malay peninsula. It makes a good avenue tree and has been planted near temples, wells and other spots subject to adoration. It grows into a large tree of upright habit, is very resistant to drought and survives light frosts. It ascends to 5,000 feet elevation in the outer Himalayas.

The peepul tree is easily recognized among figs by its very striking and peculiar leaves, which are large, heart-shaped and terminated by a slender acumen or tail one to three inches long. The petioles of the leaves are long, slender and very flexible, so the leaves oscillate freely with the slightest breeze. Fruits of the peepul are about a half inch in diameter, and dark purple when ripe.

Ficus religiosa is among the fig trees already approved for use in our forestry work. There are many fine trees growing in Honolulu, the largest specimen being that in the grounds of St. Louis College. Three splendid trees are conspicuous in the Moanalua gardens and one old specimen occurs in Mrs. Foster's garden.

We have grown many young peepul trees from seed and planted them out in the forest. We find it inadvisable to use them above 2,000 feet elevation on Hawaii, however, because they are so severely attacked by the Olinda beetle, which keeps them stripped of foliage.

Rumphius' Fig.

This tree, named *Ficus Rumphii*, after the famous Dutch botanist, Rumphius, is a close relative of the peepul and is in fact so very similar to it that it is often confused with the peepul even by the native residents of India. Its leaves have much the same shape, texture and venation as those of the peepul, but their blades are truncate instead of cordate at the base and they do not end in nearly so long an acumen.

As far as we have been able to determine, there is only one tree of *Ficus Rumphii* in these Islands, and that is growing in Mrs. Foster's garden on Nuuanu avenue. We have reared numerous young trees from seed obtained from India and Siam, and have also grown a few from cuttings taken from the tree in Mrs. Foster's garden.

Rumphius' fig is so similar to the peepul in habit that it probably will not grow under conditions which are unsuited to the peepul, and as the latter is the superior tree, we should strive to propagate it in preference to Rumphius' fig.

The Rough-Leaved Fig.

Ficus hispida is peculiar among the figs in that its leaves are borne opposite instead of alternate on the twigs. Its fruits are also borne in a peculiar manner, being formed on special short leafless shoots which spring in clusters from the main trunk and larger branches. It is not a large growing tree, but is extremely virile and spreads of itself quite rapidly. It also has a peculiar habit of sending up from its roots new shoots which eventually become new trees. While the

banyan walks over the landscape, the rough-leaved fig crawls under it, but it captures new territory for itself quite as effectually as does the banyan.

Ficus hispida is not a large tree; in fact, it is usually described as a small or medium sized tree. It is an extremely vigorous and aggressive tree, spreading itself quite rapidly by root-suckers and by seed when the proper wasp is associated with it. It is indigenous over a very large area, its range extending from the Himalayas of India and Southern China in the north to the northern part of Australia in the south. It is very common on the Island of Hong Kong.

We know of only one tree of *Ficus hispida* in Honolulu, that being in Mrs. Foster's garden. From cuttings taken from this specimen we have started many new trees and some of those planted in the Manoa arboretum have made exceedingly rapid growth. We are now growing many thousand seedlings of this species from seed obtained in Australia by Mr. Pemberton. These trees will be available for distribution next winter.

Ficus Infectoria.

This is a tall growing, wide spreading tree of stately character. It is deciduous, remaining leafless for a short period each year. It is a common component of natural forests over a very wide range, extending from China throughout India, Ceylon and Malaya. It ascends to 5,000 feet elevation in the Himalayas. It is frequently found on steep, barren slopes anchored in the crevices of rocks. It produces figs in abundance when properly placed, but these are quite small, being only one-fourth to one-third of an inch in diameter.

Ficus infectoria is a rapidly growing tree and should make a very efficient member of the plant societies which we wish to build on our watersheds. Up to the present time we have found but one tree of this species in Honolulu, and that is a very large specimen located in Mrs. Foster's garden. Cuttings from this tree strike readily and we now have several fine young trees developing in the Manoa arboretum.

Other Oriental Fig Trees.

The genus *Ficus* contains some 700 species, over four-fifths of which are native to the Indo-Malayan region.

In the foregoing paragraphs we have enumerated and described only such species as are already represented in Hawaii by mature specimens and which we know would prove to be desirable trees in the new forests which we wish to create on our watersheds. There are a few other Oriental figs already represented in Hawaii by fruiting specimens of moderate size, but we have not yet been able to identify the species or fully determine their forestry value. None of them appear to be as desirable trees for our forests as the Indiarubber, the Chinese banyan or the peepul tree.

In a recent number of the "Record," ~~F.~~ X. Williams described the more striking fig trees that are to be found in the native forests in the Philippines. Many of these develop into magnificent trees in their natural haunts, and if they

will do as well in Hawaii they will prove most valuable additions to our new flora. From seed which Mr. Williams secured, we are now growing large numbers of seedlings of some fifteen species of Philippine figs. These will be planted out in our forests on various parts of these Islands and if they develop into serviceable forest trees we may eventually introduce the wasps associated with them and thus convert them into self propagating components of our new forests. We are likewise growing seedlings of some ten fig trees of exceptional promise from seed obtained from Java, India, Burma and Siam. It will, of course, be several years before we can accurately judge the forest value of these trees under Hawaiian conditions. The only way we can obtain the desired information is to plant out the trees and await results. This of course applies only to species which have not yet been tried out under Hawaiian conditions. Those described in detail above are already represented by one or more thrifty specimens and have demonstrated their ability to grow and thrive under local conditions, and we may plant them out on our watersheds with full assurance that they will do all that we expect of them.

Earthworms and Their Culture in Relation to Agriculture.

By F. Muir.

One of the most fascinating works of Charles Darwin is "Vegetable Mould and Earthworms" Like many of his works it is written so clearly and simply that no technical knowledge is required to understand and appreciate the evidence brought together and the conclusions to be derived from it.

To anyone considering the matter for the first time without any previous information on the subject, it appears incredible that such soft, comparatively small creatures as earthworms could play any important part in nature. Yet it has been demonstrated that they are responsible for the entire or greater portion of the vegetable mould that covers a large portion of the surface of the land, and which plays such an important part in the lives of men on account of its value for agriculture.

Without agriculture, man is a semi-wild animal living by hunting or roaming about with herds of cattle. So far as worms have prepared large areas of the earth for agriculture, or for good pasture lands, so far have worms contributed to the civilization of mankind.

The long, cylindrical and segmented appearance of earthworms is familiar to almost everyone. The body wall is formed of three layers: an outer epidermis, under this a layer of circular muscle-fibres, and beneath this a layer of longitudinal muscles. Arising from the epidermis are a number of hairs or chaetae which evidently serve as passive organs of locomotion. By the alternate contraction and expansion of the longitudinal and circular muscles the worm can make itself thick and short or long and thin, and by the aid of these passive organs of locomotion a

hold can be gotten on the surface of the soil or in the burrow. If we cut a worm longitudinally and open the body wall, the digestive tube is seen to be running from end to end perfectly straight. At the anterior end the mouth forms a sucker; this leads into the buccal cavity; then into a larger cavity, the pharynx; then into a narrower aesophagus which is long, muscular, with thick walls, and enlarges into a crop; and then into a gizzard. This gizzard has very thick muscular walls and a stout lining of chitin. The remainder of the digestive tube is the wider intestine which is large and opens at the posterior end of the worm. On the aesophagus are three pair of calciferous glands which are remarkable, for nothing like them is known in other animals. It is suggested that their secretions neutralize the humus acids of the food. The gizzard crushes and grinds the food and small bits of stones are generally found in it.

Worms live in the soil in burrows which they make by either forcing or eating their way through the loose soil. With their head at the bottom of the burrow they excavate the soil with their mouth and swallow it. This is then cast out at the mouth of the burrow as "casts." Worms generally live near the surface. In dry or cold weather they penetrate to considerable depths and are found even to sixty-six inches below the surface. Their burrows are lined with fine dark soil voided by the worm, the entrance often being lined with bits of leaves and closed with small stones and other objects. The food consists of vegetable matter which they get by swallowing bits of leaves etc., or by swallowing soil containing vegetable matter. Darwin showed that they exercise considerable intelligence in selecting their food and in dragging it into their burrows.

This action of burrowing into the soil and voiding the excavated soil onto the surface causes the ground to be perforated with many burrows. These, in the course of time, collapse and the soil cast up settles down. As only fine soil is swallowed, this means that in the course of years the top surface consists entirely of soil sifted through the digestive tubes of worms, ground in their gizzard, mixed with remains of leaves and other vegetable matter and saturated with their secretions, and its whole chemical and mechanical nature considerably changed.

When we consider a single worm, the above all seems very impractical even if theoretically true. It is only when we realize the wide distribution of worms and their numbers that we can realize the great part they play in nature's economy.

In Europe it was estimated by Hansen that in a kitchen garden there are 53,767 living worms in an acre, there being nine burrows in two square feet. Worms would not be so numerous in poorer soils, but even if we take half this number as an average it gives astonishing results.

From a series of observations in different localities it is calculated that twenty ounces of soil are ejected by each worm annually. This would give fifteen tons as the weight of the castings annually thrown up on an acre of land.

The work of worms, turning up the soil and burying objects, has been demonstrated by actual experiments. Objects, such as chalk, coal, etc., scattered over the surface of pasture land soon disappears, and if dug up after a number of years are found to be some distance below the surface, all in the same plane, thus showing that the whole surface has sunk at a uniform rate. Five experiments showed the following results in different soils after ten years: 2.2 inches, 1.9

inches, 2.1 inches, 2.2 inches, 0.83 inches. This would give an average of nearly .2 inch a year.

A considerable portion of Darwin's work is to show that large objects, such as stones, buildings and pavements have been buried to considerable depths by the action of worms. He also points out the great part they play in the geology of the land.

The following passages from Darwin's work give his conclusion as to the value of worms as agriculturists:

Worms have played a more important part in the history of the world than most persons would at first suppose. In almost all humid countries they are extraordinarily numerous, and for their size possess great muscular power. In many parts of England a weight of more than ten tons (10,516 kilogrammes) of dry earth annually passes through their bodies and is brought to the surface on each acre of land; so that the whole superficial bed of vegetable mould passes through their bodies in the course of every few years. From the collapsing of the old burrows the mould is in constant though slow movement, and the particles composing it are thus rubbed together. By these means fresh surfaces are continually exposed to the action of the carbonic acid in the soil, and of the humus-acids which appear to be still more efficient in the decomposition of rocks. The generation of the humus-acids is probably hastened during the digestion of the many half-decayed leaves which worms consume. Thus the particles of earth, forming the superficial mould, are subjected to conditions eminently favorable for their decomposition and disintegration. Moreover, the particles of the softer rocks suffer some amount of mechanical trituration in the muscular gizzards of worms, in which small stones serve as mill-stones. . . . .

Worms prepare the ground in an excellent manner for the growth of fibrous-rooted plants and for seedlings of all kinds. They periodically expose the mould to the air, and sift it so that no stones larger than the particles which they can swallow are left in it. They mingle the whole intimately together, like a gardener who prepares fine soil for his choicest plants. In this state it is well fitted to retain moisture and to absorb all soluble substances, as well as for the process of nitrification. The bones of dead animals, the harder parts of insects, the shells of land-molluscs, leaves, twigs, etc., before long are all buried beneath the accumulated castings of worms, and are thus brought in a more or less decayed state within reach of the roots of plants. Worms likewise drag an infinite number of dead leaves and other parts of plants into their burrows, partly for the sake of plugging them up and partly as food.

The leaves which are dragged into the burrows as food, after being torn into the finest shreds, partially digested, and saturated with the intestinal and urinary secretions, are commingled with much earth. This earth forms the dark colored, rich humus which almost everywhere covers the surface of the land with a fairly well-defined layer or mantle. . . . .

It is believed by some persons that worm burrows, which often penetrate the ground almost perpendicularly to a depth of five or six feet, materially aid in its drainage; notwithstanding that the viscid castings piled over the mouths of the burrows prevent or check the rain-water directly entering them. They allow the air to penetrate deeply into the ground. They also greatly facilitate the downward passage of roots of moderate size; and these will be nourished by the humus with which the burrows are lined. Many seeds owe their germination to having been covered by castings; and others buried to a considerable depth beneath accumulated castings lie dormant, until at some future time they are accidentally uncovered and germinate. . . . .

When we behold a wide, turf-covered expanse, we should remember that its smoothness, on which so much of its beauty depends, is mainly due to all the inequalities having been slowly levelled by worms. It is a marvellous reflection that the whole of the superficial mould over any such expanse has passed, and will again pass, every few years through the bodies of worms. The plough is one of the most ancient and most valuable of man's

inventions; but long before he existed the land was in fact regularly ploughed, and still continues to be thus ploughed by earthworms. It may be doubted whether there are many other animals which have played so important a part in the history of the world, as have these lowly organized creatures. Some other animals, however, still more lowly organized, namely corals, have done far more conspicuous work in having constructed innumerable reefs and islands in the great oceans; but these are almost confined to the tropical zones.

Turning from earthworms to a closely related family, Enchytraeidae, we find that recent investigations indicate that these little creatures, hitherto considered as of no importance to agriculture, possibly play an important role. These are small or minute worms, mostly considerably less than an inch in length, that live in soil or water and are common in soils in most parts of the world. G. Jegen, a biologist in Europe, has been studying the habits of some of these worms and finds that they live upon nematodes, such as the destructive *Tylenchus devastatrix* and *Aphelenchus ormeroides.* When we consider how harmful nematodes are to crops in many parts of the world the value of these little worms becomes apparent.

Does all this information about "worms" have any bearing upon agriculture in Hawaii?

If we turn to the "Fauna Hawaiiensis," the store house of information of the land animals of our islands, we find that Dr. Perkins collected twelve species of earthworms, mostly in out of the way places in the mountains where native species were most likely to be found. Of these twelve only one is doubtfully native, all the others being found in various parts of the world, and were evidently introduced by man comparatively recently. It is doubtful if earthworms existed in the islands before the advent of the white men. Most of our worms have evidently been brought from Asia as several of the species found here have been taken in Hongkong.

A characteristic of the soils of these islands is a comparative absence of the layer of vegetable mould found in many parts of the world, even in our moister districts. We have deep, fine soils in some parts, but these are comparatively free from humus and in our damp forests where conditions are ideal for the accumulation of vegetable mould we do not find that 18 to 24 inches of fine, well shifted mould rich in vegetable matter, in anything like the same proportion as we do in many other parts of the world. Is it not possible that this is due to the absence of earthworms in these islands in long past ages?

Even now that we have accidentally acquired a dozen species or so have we those that are best suited for our soils and which are capable of doing the greatest good? In South Africa there are worms that throw up casts of 25 cubic inches or more. In our meadow lands and on our lawns our grass is very poor and thin. May it not be due to the comparative scarcity of worms throwing up the soil through which the grass grows so that in a few years' time the turf is thick? These are all questions into which it is well worth inquiring.

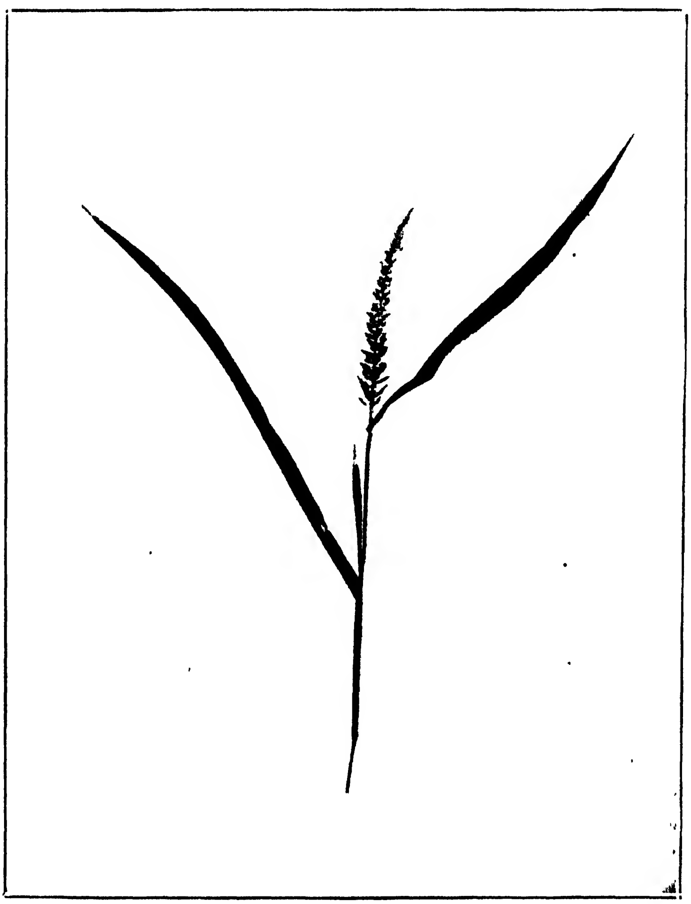
Of the Enchytraeidae we have no single example in the island so far as is known at present. Would it not be well to inquire further into the habits of these worms in Europe and elsewhere where Nematodes are not reported as being so very injurious, and where agriculture has been carried on for many hundreds of years?

The more we know of nature, the more we find that the destiny of the human race is bound up more with the smaller creatures of the universe than with the greater.

Mosaic Disease on a New Grass Host.

By L. O. Kunkel.

It has recently been observed that the wild grass *Chaetochloa verticillata,* which is a rather common weed in cane fields and along roads and watercourses, is subject to mosaic. The disease often attacks this host severely, causing a marked discoloration of the leaves and a stunting of the whole plant. It closely resembles the mosaic on sugar cane and may be the same disease. This possibility brings the grass under suspicion as a means of spreading mosaic to cane. Experiments to determine this point are now under way. In the meantime it should be looked on as a dangerous weed.



Chaetochloa verticillata.

Chaetochloa verticillata, which is one of the bristly, foxtail grasses, is an annual. It grows in dense tufts and reaches a height of from one to two feet. Seed is produced in cylindrical spike-like panicles. The panicles, especially when ripe, readily become attached to clothing by means of downwardly barbed bristles which surround the spikelets. The accompanying illustration, which shows a portion of a mature plant, may be of aid in identifying the grass.

Experiments at Oahu Sugar Company.

By J. A. VERRET.

GENERAL.

These experiments are on the Oahu Sugar Company plantation in field 45 B at an elevation of about 550 feet.

About half the area of this experiment was in Lahaina cane and was suffering severely from Root-rot or so-called Lahaina disease. It was therefore decided to harvest this field early and plow it up in order to plant some other variety of cane. The 1920 crop was harvested in November, 1920, and the last one in February, 1922, the cane being fifteen months old at the time.

The cane juices were taken from carload lots at the mill.

This is the third crop harvested from these experiments; the first crop, in 1918, was planted on virgin land.

The results of the 1920 and 1922 crops from this area show in an interesting way the advantage of reporting sugar yields on the basis of "sugar per acre per month" rather than "sugar per acre" only.

The yield in 1920 from a series of plots receiving uniform treatment amounted to 13 tons of sugar per acre. The yield from the same plots in 1922 was 5¼ tons of sugar. At first sight this appears to be a tremendous difference. On closer study of the records, however, we find this difference to be more apparent than real.

The 1920 crop occupied the land from March 1918 to November 1920, a period of 32 months. The 1922 crop occupied the land from November 1920 to February 1922, a period of 15 months.

The amount of sugar actually produced per acre per month for these two crops figures out as follows:

1920 crop=0.413 ton p. a. p. m.
1922 crop=0.347 " " " " "

This is a difference of only 16%.

The results obtained in this field are briefly summarized as follows:

1st. Varieties: Lahaina, Striped Mexican, H 146, H 109, Badila, Yellow Caledonia, H 333, H 227 and D 1135 were compared. Lahaina and H 146 failed on account of Root-rot. H 333 was killed by Eye-spot. H 227 and Yellow Caledonia did not do well. H 109 and D 1135 gave the best yields. H 456, Badila, and Striped Mexican did fairly well.

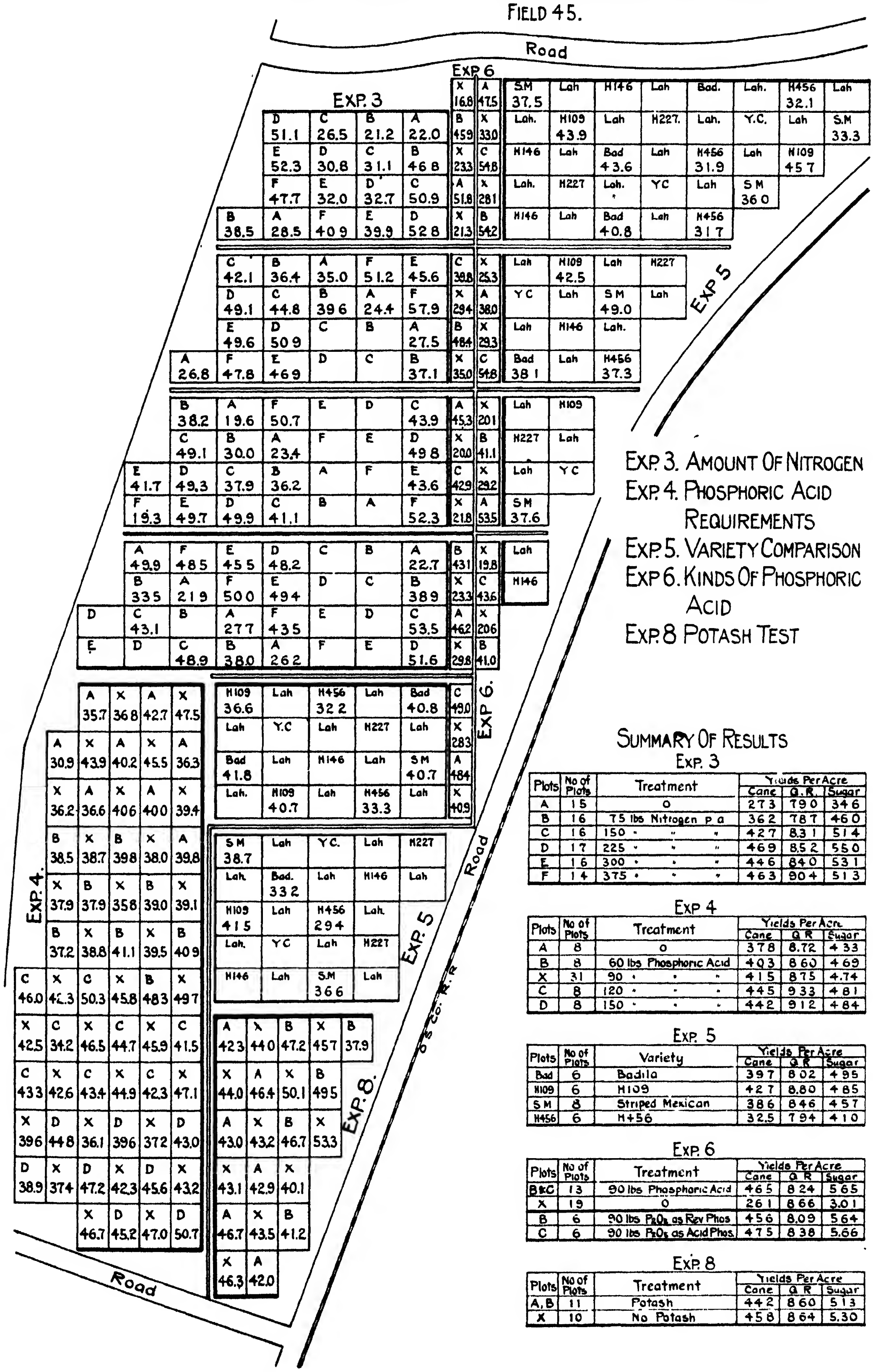
2nd. The economic response to nitrogen fertilization varied from 150 to 225 pounds per acre, the average being 200 pounds. This would be supplied by say 900 pounds of high grade containing 11% nitrogen and 650 pounds of nitrate of soda.

3rd. Potash was of no value in increasing yields.

4th. The response to phosphoric acid fertilization was large. From 90 to 120 pounds per acre of P_2O_5 (550 to 700 pounds of acid phosphate) can be used to advantage.

Oahu Sugar Co. Expts. 3,4,5,6,& 8, 1922 Crop

Field 45.



Exp. 3. Amount Of Nitrogen

Exp. 4. Phosphoric Acid Requirements

Exp. 5. Variety Comparison

Exp. 6. Kinds Of Phosphoric Acid

Exp. 8 Potash Test

Summary Of Results

Exp. 3

Plots	No of Plots	Treatment	Yields Per Acre		
			Cane	Q.R.	Sugar
A	15	O	273	790	346
B	16	75 lbs Nitrogen p a	362	787	460
C	16	150 " " "	427	8.31	514
D	17	225 " " "	469	8.52	550
E	16	300 " " "	446	840	531
F	14	375 " " "	463	904	513

Exp 4

Plots	No of Plots	Treatment	Yields Per Acre		
			Cane	Q R	Sugar
A	8	O	378	8.72	433
B	8	60 lbs Phosphoric Acid	403	860	469
X	31	90 " " "	415	875	4.74
C	8	120 " " "	445	933	481
D	8	150 " " "	442	912	484

Exp. 5

Plots	No of Plots	Variety	Yields Per Acre		
			Cane	Q R	Sugar
Bad	6	Badila	397	802	495
H109	6	H109	427	8.80	485
S M	8	Striped Mexican	386	846	457
H456	6	H456	32.5	794	410

Exp. 6

Plots	No of Plots	Treatment	Yields Per Acre		
			Cane	Q R	Sugar
B&C	13	90 lbs Phosphoric Acid	465	824	565
X	19	O	261	866	3.01
B	6	90 lbs P_2O_5 as Rev Phos	456	8.09	564
C	6	90 lbs P_2O_5 as Acid Phos	475	838	5.66

Exp. 8

Plots	No of Plots	Treatment	Yields Per Acre		
			Cane	Q R	Sugar
A, B	11	Potash	442	860	513
X	10	No Potash	458	864	5.30

Experiment No. 3—Amounts of Nitrogen.

All plots received phosphoric acid and potash. The amounts of nitrogen used varied from nothing to 375 pounds per acre. The cane was D 1135.

The tons of sugar obtained for three crops are as follows:

Treatment	Yield per Acre		
	1918 21 Months	1920 32 Months	1922 15 Months
No nitrogen	5.93	9.00	3.46
75 pounds nitrogen.............	6.73	10.20	4.60
150 " "	7.30	11.38	5.14
225 " "	7.71	10.95	5.50
300 " "	7.41	10.94	5.31
375 " "	7.69	10.81	5.13

The effect of varying amounts of fertilizer on the quality of the juices is shown below:

QUALITY RATION OF JUICES FROM EXPERIMENT NO. 3

Treatment	1918 Crop	1920 Crop	1922 Crop	Average
No nitrogen................	9.38	7.11	7.90	8.13
75 pounds nitrogen.........	9.69	7.32	7.87	8.29
150 " "	9.91	7.96	8.31	8.73
225 " "	9.94	8.53	8.51	8.99
300 " "	10.61	8.47	8.40	9.16
375 " "	10.93	8.64	9.04	9.54

The 1918 crop was harvested in March, the 1920 in November, and the 1922 in February. The last fertilization to the 1918 crop was applied in July 1917, for the 1920 and 1922 crops, it was applied in May. That was in all cases too late for best results, especially when the cane is harvested early.

The juices show a continued lowering in quality as the amounts of nitrogen are increased. The figures with which we are mostly concerned are those showing the difference between 150 and 225 pounds of nitrogen per acre. When the nitrogen is increased from 150 to 225 pounds, the quality ratio is raised 0.26 ton of cane, amounting to about 3%. Getting the cane to the mill one day sooner after burning would just about make up for this.

But it must be distinctly recognized that increasing the nitrogen fertilizer has a tendency to lower the quality of the juices, all other things being equal. Up to a certain point, this is more than made up by increased cane tonnage. In order to avoid this as much as possible the second season fertilization should be finished as early as practical. The results of our fertilizer experiments lead us to believe heavy fertilization finished in March will give as good juices as lighter applications in June or July.

Details of Experiment.

Amount of nitrogen to apply—0, 75, 150, 225, 300, and 375 lbs. nitrogen per acre.

Object:

To determine the most profitable amount of nitrogen to apply to 2nd ratoons, long. Note: In the plant and first ratoons preceding the present crop, the three plant foods, nitrogen, phosphoric acid, and potash, were applied in variable quantities. For this crop, phosphoric acid and potash are applied uniformly to all plots, nitrogen being the only variable.

Location:

Field 45, sections 1, 2, 3, and 4 of the experimental area in this field, Kunia side of the straight ditch.

Crop:

Lahaina and D 1135, 2nd ratoons, long.

Layout:

No. of plots: 94.
Size of plots: 1/10 acre each (79.2′ x 55′) consisting of 20 single rows (or 10 double rows). Each plot two watercourses in width; each single row 1/200 acre. These areas include watercourses. For level and straight ditches add 2.5%.

Plan:

Fertilization—pounds nitrogen per acre:

Plots	No. of Plots	As M.F. Jan.-Feb. 1921	As N.S. May-June 1921	Total Lbs. Nit.
A	15	0	0	0
B	16	37.5	37.5	75
C	16	75.0	75.0	150
D	17	112.5	112.5	225
E	16	150.0	150.0	300
F	14	187.5	187.5	375
Cane Crop	17.6	75.0	75.0	150

All plots to receive uniform dose of 150 pounds of P_2O_5 as acid phosphate, including that in mixed fertilizer, and 50 pounds K_2O applied in a separate dressing, Jan.-Feb. 1921.
M. F.=mixed fertilizer 11% N. (7% sulf., 3% nitrate, 1% organic.); 9% P_2O_5 (super bonemeal).
N. S.=nitrate of soda 15.5% N.

Experiment No. 4—Amounts of Phosphoric Acid and Potash.

In this test all plots received nitrogen at the rate of 200 pounds per acre. The amounts of phosphoric acid and potash were varied. The results obtained from the D 1135 for three crops are given as follows:

1918 CROP—PLANT

Treatment			Yield Per Acre			Gain in Sugar over Plots Getting Nitrogen Only
N.	P_2O_5	K_2O	Cane	Q. R.	Sugar	
200	30	20	59.4	9.68	6.14	+0.68
200	0	0	51.8	9.47	5.46	
200	60	40	60.5	9.71	6.23	+0.78
200	0	0	50.4	9.26	5.45	
200	90	60	64.8	10.51	6.17	+1.40
200	0	0	49.1	10.28	4.77	
200	120	80	65.5	11.02	5.95	+1.37
200	0	0	47.7	10.19	4.68	

1920 CROP—1st RATOONS

Treatment			Yield Per Acre			Gains Over Nitrogen Plots
N.	P_2O_5	K_2O	Cane	Q. R.	Sugar	
200	30	20	78.7	7.17	10.98	+1.92
200	0	20	67.6	7.46	9.06	
200	60	40	89.5	7.73	11.57	+2.00
200	0	20	71.0	7.46	9.57	
200	90	60	91.0	7.59	12.22	+2.02
200	0	20	76.0	7.46	10.20	
200	120	80	99.5	7.21	13.79	+4.71
200	0	20	67.8	7.56	9.08	

1922 CROP—2nd RATOONS

Treatment			Yield Per Acre			Gain Due to Phos. Acid
N.	P_2O_5	K_2O	Cane	Q. R.	Sugar	
175	0	50	37.8	8.72	4.33	
175	60	50	40.3	8.60	4.69	+0.36
175	90	50	41.5	8.75	4.74	+0.41
175	150	50	44.5	9.33	4.81	+0.48
175	180	50	44.2	9.12	4.84	+0.51

The soil in this field is high in potash. In an adjoining area no gains were obtained from potash. Therefore the gains obtained here are due to the phosphoric acid.

These results indicate that economic ~~gains~~ are obtained in phosphoric acid applications of from 90 to 120 pounds of P_2O_5 per acre. This corresponds to from 550 to say 700 pounds of acid phosphate.

Details of Experiment.

PHOSPHORIC ACID—AMOUNT TO APPLY.

Object:

To determine the most profitable amount of phosphoric acid to apply to these mauka lands. Comparing 60, 90, 120, 150, and 180 pounds per acre.

Location:

Field 45, section 11 of the experimental area.

Crop:

Lahaina, D 1135 and H 109, 2nd ratoons, long.

Layout:

Number of plots: 63.
Size of plots: 1/10 acre each (79.2′ x 55′) consisting of 20 single rows (or 10 double rows). Each plot is 2 watercourses wide; each single row 1/200 acre. These areas include watercourses. For level and straight ditches add 2.5%.

Plan:

Fertilization—pounds per acre:

Plots	No. Plots	Jan.-Feb. 1921			May-June 1921	Total Lbs. per Acre		
		N	P_2O_5	K_2O	N	N	P_2O_5	K_2O
A	0	87.5	60	50	87.5	175	60	50
B	8	87.5	90	50	87.5	175	90	50
X	31	87.5	120	50	87.5	175	120	50
C	8	87.5	150	50	87.5	175	150	50
D	8	87.5	180	50	87.5	175	180	50
Crop C	11.3	87.5	120	—	87.5	175	120	..

N and P_2O_5 from mixed fertilizer=11% N (7% Sulph., 3% Nit., 1% Org.);
and 9% P_2O_5 (Super bonemeal)
Nitrate of soda=15.5% N.
Potash from sulphate = 50.0% K_2O.

EXPERIMENT NO. 5—VARIETIES.

In this experiment Lahaina, Striped Mexican, H 109, H 146, H 227, H 333, Badila, Yellow Caledonia and H 456 are compared.

From the results of three crops, one plant and two ratoons, Yellow Caledonia, H 227, H 333, Lahaina and H 146 were found not suited to this locality. Lahaina and H 146 developed Root-rot. Yellow Caledonia and H 227 gave poor yields, while H 333 was killed by Eye-spot. H 109 also suffered from Eye-spot, but in this particular field this was never severe enough to prevent it from giving good yields.

The yields in tons of sugar from the four best varieties are given as follows for the three crops:

TONS SUGAR PER ACRE.

Variety	1918	1920	1922	Average
H 109	8.80	12.80	4.85	8.82
Str. Mex.	8.24	10.45	4.57	7.79
Badila	7.90	9.43	4.95	7.43
H 456	...	10.55	4.10	7.33

D 1135 grown in adjoining areas gave yields approximating those of H 109.

Details of Experiment.

Object:

VARIETY TEST.

To compare Lahaina with Striped Mexican, H 109, H 146, H 227, H 456,* Badila and Yellow Caledonia. (Second ratoons, long.)

Location:

Field 45, sections 4, 5, 7, 8, 9, and 10 of the experimental area of this field.

Crop:

Varieties as above, 2nd ratoon long except H 456 which is first ratoon long.

Layout:

No. of plots: 99.
Size of plots: 1/10 acre each (79.2'x 55'), consisting of 20 single rows (or double rows). Each plot is 2 watercourses wide. Each single row is 1/200 acre. These areas include watercourses. For level and straight ditches 2.5% should be added.

Plan:

Fertilization uniform to all plots as follows:

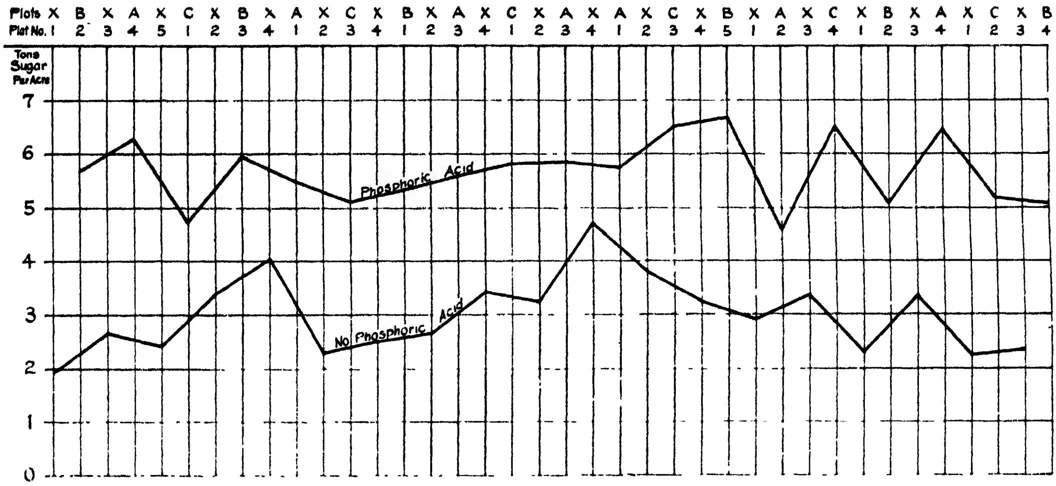
	Jan.-Feb. 1921		May-June 1921	Total Lbs.
	M. F.	Acid Phos.	N. S.	
Nit.	75		75	150
P_2O_5	61	92		153

Experiment originally planned by L. D. Larsen.
Experiment originally laid out by J. S. B. Pratt.
Experiment harvested by Y. Kutsunai.
* For 1920 crop H 456 was substituted for H 333.
M. F.=11% (7% sulf., 3% nit., 1% org.)
9% P_2O_5
Acid Phosphate=17% P_2O_5

EXPERIMENT NO. 6—PHOSPHORIC ACID.

The main purpose of this experiment was to compare equal amounts of P_2O_5 from acid phosphate and from reverted phosphate.

PHOSPHORIC ACID VS. NO PHOSPHORIC ACID.
Oahu Sugar Co. Exp. 6, 1922 Crop
2nd Ratoons, Long



The results in tons of sugar from three crops were as follows:

Treatment	Tons Sugar per Acre			Average Per Crop
	1918	1920	1922	
90 lbs. P_2O_5 from Acid phos.	8.40	14.29	5.66	9.45
90 lbs. P_2O_5 reverted phos.	8.17	15.46	5.64	9.75

Comparing phosphates with no phosphates we obtained the following results:

Treatment	Tons Sugar Per Acre			Average Per Crop
	1918	1920	1922	
90 lbs. P_2O_5 per acre	8.28	14.87	5.65	9.60
No phosphates	7.07	12.38	3.01	7.47

Details of Experiment.

PHOSPHORIC ACID EXPERIMENT.

1. Reverted phosphate.
2. Super phosphate.
3. No phosphate.

Object:

To determine the value of applying reverted phosphate as against applying acid phosphate or no phosphate.

Note: This is a duplication of the experiment as laid out for the 1918 crop requiring harvesting data from two consecutive crops.

Location:

Field 45, divisions 1 on both sides of the straight ditch which runs through the experimental area.

Crop: H 109, second ratoon, long.

Layout:

No. of plots: 38.

Size of plots: 1/22 acre each (36′ x 55′) consisting of 10 single rows each 5.5′ x 36′. Each plot is one watercourse in width and each single row is 1/220 acre. These areas include watercourses. For level and straight ditches add 2.5%.

Plan:

"A" plots=180 lbs. per acre of phosphoric acid as reverted phosphate applied Jan. 1921—to last for two crops.

"B" plots=90 lbs. per acre of phosphoric acid as reverted phosphate applied Jan. 1921 to each crop.

"C" plots=90 lbs. per acre of phosphoric acid as acid phosphate applied in January to each crop.

"X" plots=No phosphoric acid.

All plots to receive uniform dose of 175 lbs. nitrogen in two equal doses and 50 lbs. potash in one dose.

Nitrogen from nitrate of soda—15.5% N.

Potash from sulfate of potash—50.0% K_2O.

Experiment No. 8—Potash.

We here tested the value of potash applications to a soil high in total potash, 0.80%.

The results show no gains from the use of potash. The yields for the two treatments follow:

Treatment	Yield per Acre		
	Cane	Q. R.	Sugar
Potash	44.2	8.60	5.13
No Potash	45.8	8.68	5.30

Details of Experiment.

POTASH.

Object:

To determine the value of potash on the mauka land of Oahu Sugar Co.

Location:

Field 45, in the makai Kipapa corner of the experimental area of this field (Section 12).

Crop:

Lahaina and D 1135 with H 109 crop cane.

All 2nd ratoons long.

Layout:

No. of plots: 21.

Size of plots: 1/10 acre each (55′ x 79.2′) consisting of 20 single rows (10 double rows). Each plot two watercourses in width; each single row 1/200 acre. These areas include watercourses. For level and straight ditches add 2.5%.

Plan:

Fertilization—pounds per acre:

Plots	No. Plots	Jan.-Feb. 1921			May-June 1921	Total Lbs. per Acre		
		N	P_2O_5	K_2O	N	N	P_2O_5	K_2O
A & B	11	87.5	120	100	87.5	175	120	100
X	10	87.5	120	0	87.5	175	120	0

Nitrogen in first dose applied as mixed—11% (7% Sulf., 3% Nit., 1% Org.); 9% P_2O_5).

Nitrogen in second dose applied as N. S. 15.5% N.

Phosphoric acid applied as mixed with supplementary dose of acid phosphate.

Experiment planned by R. S. Thurston.

Entomological Work in the Philippines.

September 1920—April 1922.

By Francis X. Williams.

With the exception of a week's stay in Hongkong, China, the work abroad was confined to the Philippine Islands.

Object of the Work.

This was to secure natural enemies of the wireworms, *Monocrepidius exsul* and *Simodactylus cinnamomeus*, which have caused damage to some of the Hawaiian cane fields; to import the fig-wasp which pollinates the flowers of *Ficus retusa*, of which several trees grow in Hawaii; and to study and establish such other beneficial insects as opportunity offered. In addition, some effort was made to gather seeds of trees which would aid the reforestation work in Hawaii.

Islands Visited.

Ten islands of the Philippine group were visited. Some of these were comparatively small and unimportant and my stay there—incident to a longer journey - was brief; the larger islands, especially those more or less given over to the cultivation of sugar cane necessitated a residence of some days or weeks. Proceeding from north to south the following islands were visited: Luzon, Polillo, Mindoro, Romblon, Panay, Cebu, Negros, Mindanao, Jolo and Siasi. Everywhere assistance was gladly extended to me. At the College of Agriculture, Los Baños, Luzon, library, laboratory, and insectary facilities were available as well as the aid of the capable scientific staff of that institution. The same was the case with the Forest School there, and of the Bureaus of Forestry and of Science in Manila. Government Experiment Stations, the Sugar Centrals and Haciendas all made work easier, and to them thanks are also due.

Luzon, the largest of the Philippine group is about ten times the area of the Island of Hawaii. Here most of the investigations were carried on at the College of Agriculture, Los Baños, an excellent place to study entomological or botanical problems. The College, part of the University of the Philippines, lies some forty miles southeast of Manila and is in a sugar cane district. The Calamba Sugar Estate is nearby, and the District of Lipa, only a few miles further. The Del Carmen Sugar Central, in Pampanga north of Manila Bay, was twice visited. In Mindoro, a few days were spent at the Mindoro Sugar Estate Company on the southwest coast. In Panay, the sugar cane about Iloilo and that of Capiz Central to the north were investigated. In Cebu, a trip was made to Bogo towards its northern end, where considerable sugar cane is grown.

The Island of Negros, which is somewhat larger than that of Hawaii is of rather elongate form and in many places the land extends, as a long slope, up to the central mountain mass, thus affording extensive areas for the growth of cane.

Here, especially in Occidental Negros, modern centrals have almost done away with the operation of the crude muscovado sugar mills which dot the country. This island proved the most promising of any for the investigation of sugar cane insects.

Mindanao, the big island to the south is nearly as large as Luzon, and the richest in the Archipelago. Here the sugar industry is only in its infancy. A little cane was investigated at Zamboanga, its chief seaport and also at Iligan on the north coast. The varieties of sugar cane planted, as regards area, are still prevailingly of the native types introduced years ago. Negros Purple and Cebu Purple are such, and are planted over extensive areas. In many places cane is grown on a small scale and is sold in the native stores, a few sticks at a time, for individual or family consumption. Occasionally one may find a few varieties of rather striking appearance in the market places of the southern islands.

WIREWORM PARASITES.

These were not found. As far as I could ascertain wireworms are not a recognized pest of Philippine agriculture and the majority of sugar men were unacquainted with the appearance of the larva. Nevertheless many species inhabit the Archipelago. As a rule they were found in small numbers in the larval stages. Aside from a quite small species whose larva was once found associated with a little bethylid wasp there was no appearance of parasitism. This small wireworm was abundant locally in July 1921 at Del Carmen Central, and full fed was about 8 mm. long. About Los Baños, a few specimens of wireworm larvae of several kinds were unearthed, both in the field and in the forest. Some of the *Monocrepidius* type were somewhat over two inches long. Experiments with these seemed to show that they were at least preferably carnivorous and readily ate white grubs and other wireworm larvae. Here and there wireworms were dug up. At Silay, Negros Occidental, fallow cane fields yielded a few *Monocrepidius* or related larvae, in September, 1921. At Isabela Central, farther south and on the same island I was told of a wireworm infestation, and investigation showed *Monocrepidius* or an ally in fairly good numbers and more or less associated with a large lamellicorn beetle grub infesting a cane field. Here as elsewhere I found no wasps that appeared likely to parasitize *Monocrepidius* or its slenderer relatives.

Blastophaga WASPS FOR *Ficus retusa.*

Ficus retusa is a strangling fig that grows wild in the Philippines. Along the shores of a large lake at Los Baños it was a small tree or shrub on the cliffs. In the forest on Mount Maquiling it occurred as a larger tree, but was neither as tall nor as handsome as a number of other stranglers there. At Hongkong, however, it presented a very good appearance and made an excellent avenue tree. Several shipments of *F. retusa* figs bearing wasps were made to Hawaii but neither the Philippine lots nor the ones from Hongkong yielded the proper insects. Marcotting was tried as a method of transporting the *Blastophaga* in growing figs, but the plants did not show up well, and were continuously dropping their immature fruits. In connection with the work on *Ficus retusa,* many other species of figs and fig wasps were studied or collected. About fifty species of figs—some

vines, others independent trees or shrubs or stranglers—were observed on Mount Maquiling, Luzon, and seven or eight additional kinds on the more southern islands. As a forest cover figs are useful plants and some of the stranglers grow into self-supporting trees, assume very large dimensions, and are noticeable for their wide crowns and stout stems.

Parasites on the Bean Lycaenid.

Approximately 3000 eggs of a blue butterfly related to our *Polyommatus boeticus* which damages the flowers and seeds of San Hemp, Cow peas, etc., were shipped here in lots from time to time but without yielding the desired egg parasite. A very small consignment of an Ichneumonid wasp that parasitizes the larva of the Philippine butterfly was brought over and liberated at the Federal Experiment Station, as well as a somewhat larger lot of *Odynerus* wasps, one species of which stores its nest with Lycaenid caterpillars. Blue, bean butterflies are numerous in cultivated areas in the Philippines, but more so here where they have not as many enemies.

Aphid Enemies.

In the Philippines, aphids are often very abundant on legumes, crucifers, etc., but sooner or later their enemies--ladybeetles, Syrphid flies, wasps, etc.—do much to suppress them. Ladybeetles or Coccinellidae appear to be about their most efficient enemy. No aphid enemies survived shipment from Manila. Wooly aphis (*Oregma*) on cane - native and cultivated- and bamboo were found to be attacked by the larva of a small moth.

Cricket Enemies.

Mole crickets (*Gryllotalpa*) and field crickets (*Gryllus*) are pests of not much importance here. However, their reduction in Hawaii is desirable. Three species of Larridae that prey on these insects were released in Honolulu.

Dung Beetles.

These enemies of the hornfly were twice shipped in from Manila. Three species, *Onthophagus* sp, *Onites phartopus* and *Catharsius molossus* were represented, but only a few of the first reached maturity in Honolulu and were liberated. A Philippine Histerid beetle occasional under manure was shown to devour fly maggots.

Tephrosia candida and *Leucaena glauca*.

The seeds of these legumes, especially of the former, are subject to insect attack and a little time was given to studying the enemies of such seed caterpillars.

Nutgrass (*Cyperus rotundus*) Insects.

This sedge, as elsewhere in the tropics, is considered undesirable in the Philippines. In that country there are several insects which weaken or destroy this pest. Two of these were successfully shipped to Honolulu where they are being

tried out in quarantine on some agricultural plants they might injure. It would be inadvisable to liberate such insects if there was a chance of their becoming noxious here. The two insects under probation are the larva of a small moth, identified by O. H. Swezey as *Bactra* sp., which bores into the stem and to some extent into the tuber itself. The other insect, likewise a borer, is a small weevil whose grub has habits much like the caterpillar. Both pupate in the plant. In the Philippines I do not think that this combined work averages more than five per cent effective.

A species of parasitic wasp and a small Tachinid fly preys on the moth caterpillar. The beetle larva seems to have fewer enemies; it is occasionally killed by an exoparasite, the larva of a Chalcid wasp. What seemed to be the same moth caterpillar was found on nutgrass at Hongkong. A dark green Aphid occurs on the leaves, and the base and roots harbor a rather small mealybug. A small blackish flea beetle (Chrysomelidae) is occasionally found on this plant. A fungus (*Puccinea* sp.) is very common on nutgrass which it affects in considerable areas, but does not appear to kill it.

Cane Diseases and Cane Insects.

While in the sugar cane districts I had opportunity of becoming acquainted with various cane pests. Fiji disease and downy mildew were pointed out to me, and what appeared to be Yellow Stripe disease was very prevalent.

Of cane borers a number of species were noted. In Occidental Negros I took a few specimens of a beetle borer, *Mecistocerus* sp. allied to the beetle borer in Hawaii and working in about the same way in cane stems. Specimens in the H. S. P. A. Experiment Station collections show that this species occurs also in the islands to the south of the Philippines. But the borers which are conspicuous by the effects of their work are the caterpillars of certain moths of which several species were found. The moths represent three families, Pyralidae, Noctuidae and Tortricidae, the first prevailing. Some were found in "Talahib" or wild cane (*Saccharum spontaneum*), a tall grass often very abundant about cane fields and elsewhere and doubtless the original food plant of certain cane-attacking insects. Some of the caterpillars are to be found in both old and young cane, others are more or less confined to juvenile plants, plant cane or ratoon, which they attack quite early. Some of these caterpillars go by the name of "point borer," because the point is attacked and then shows as a central withered roll of leaves with one or more of the free leaves in like condition. The injury often extends well into the seed, the few tender joints of the shoot being more or less girdled, and although other shoots are produced, the growth of the cane is retarded. Point borers were found at widely different seasons and their work was sometimes very conspicuous. A few parasites on cane-boring caterpillars were found; one was a tachinid fly, another a Braconid wasp, while a borer pupa produced a number of small Chalcid like wasps.

The sugar cane aphid was not found plentiful, but a woolly aphis (*Oregma lanigera*) was often abundant, though scarcely harmful, on the underside of the leaves. What appeared to be the same insect occurred likewise on wild sugar cane. The sugar cane mealy bug, *Pseudococcus sacchari* was abundant. At North Negros many of the cane stems were found heavily attacked by a diaspine scale.

Several kinds of leafhoppers occur on cane, but are rarely found doing noticeable damage. *Cyrtorhinus* doubtless, and other enemies keep them in check.

The Migratory Locust, *Pachytylus* sp. sometimes does considerable injury to Philippine crops and migrates in clouds. In Northern Panay, what was apparently a small swarm had alighted among some sugar cane in the foothills some days before my arrival. Only a small area of cane was affected, but at every turn of the trowel one or more egg masses of this locust would be unearthed.

White Grubs.

These are generally widespread in the cane fields and sometimes cause noticeable injury. A number of species are represented but the ones about which complaints seem to be generally made are of large size and parallel the cane grubs in Queensland, Australia. A large Scoliid wasp was found in affected fields. Termites or white ants often appear secondary but sound cane may also be attacked. More than one species is involved.

In general, however, Philippine cane insects are well regulated by their enemies so that the damage done by them is more often slight, sporadic, or at least not usually of major importance.

Forest Conditions.

Some time was devoted to the study of forest conditions, with special reference to species of figs and to the collection of seeds for reforestation in Hawaii. Later a student at the College of Agriculture was employed in collecting seeds about Los Baños, and in some species large numbers were obtained. Mount Maquiling is very accessible, has an extensive flora, and at certain seasons of the year seeds of forest trees are abundant on the forest floor. Quantities of these seeds are attacked by caterpillars, weevils, etc., and it is important to gather the seeds when freshly fallen and even when still attached to the trees.

A few trips to other forests and mountains were made. The volcanic cones of Mount Banahao near Los Baños and of Canlaon in Negros were visited. Mount Banahao rises to over 7,000 feet. At 4,000 or 5,000 feet oak trees grow abundantly and three species of conifers, one of yew (*Taxus* sp.), and two *Podocarpus* occur at suitable elevations. At the summit one of the latter species prevails. Mount Canlaon is about 8,000 feet high and its deep and precipitous crater is still a little active, there being a strong smell of sulphur in the vicinity. Here, as on other high mountains, temperate zone conditions prevail, and a species of raspberry (*Rubus* sp.) of fairly palatable nature and bumble bees, absent in the lowlands of the tropics, emphasize this point.

A number of photographs of forest trees and forest scenes were taken for the department of forestry of the Experiment Station.

The Improvement of Pineapples Through Bud Selection.*

By A. D. Shamel.

Introduction.

The term bud selection is here used to mean the selection of superior parent plant materiai for propagation in those crops which are commonly propagated asexually, or, from vegetative parts. The term bud selection as applied to vegetatively propagated plants, as I interpret it, corresponds to the term seed selection as used in the case of plants propagated from seeds.

The behavior of plants under cultivation depends upon two influences, (1) heredity, and (2) environment. We will discuss the hereditary influences in the case of a few vegetatively propagated crop plants from our point of view. The environmental influences include (1) climate, (2) soil, (3) tillage, (4) plant food or fertilizers, (5) water or irrigation practices, (6) light, and (7) fungus or other diseases, insect enemies and other limiting factors. The effect of environmental influences upon plant behavior will not be dwelt upon here. The relation of hereditary influences to plant production, particularly the variations of vegetatively propagated plants under cultivation and the origin of strains from these variations, will be briefly discussed from the standpoint of the isolation, propagation and cultivation of superior strains through systematic bud selection work.

Object of Bud Selection Work.

The object of plant improvement through bud selection work from the standpoint of this discussion may be divided into two general phases, (1) the discovery of new varieties, and (2) the amelioration of established varieties. That new varieties did or could originate from bud variations in vegetatively propagated plants has been questioned by a few persons until within recent years. That an impressive number of important new varieties of cultivated plants have arisen from bud selection is now proven by an overwhelming mass of indisputable evidence. Furthermore, some of our most important cultivated varieties, heretofore believed to have originated as a result of seminal or seed variations, are now known to have arisen from bud variations. Notwithstanding the great importance to agriculture of this phase of bud selection work, which I have recently discussed in some detail elsewhere,† this discussion will be largely confined to the economic phases and possibilities of bud selection work for the improvement of existing varieties of established worth and value to agriculture.

The Improvement of Established Varieties.

The use of the term "improvement" in plant breeding has frequently been restricted solely to defining, or, as synonymous with the term, the origination of

* A lecture presented at the Short Course on Pineapple Production, University of Hawaii, 1922.

† Improvement of Plants Through Bud Selection, pub. by the Experiment Station, H. S. P. A., 1921.

new varieties. I will use it here to define the amelioration of established varieties as well as to include the origination of new varieties from bud variations. From my experience in plant improvement work I have concluded that from the commercial point of view the amelioration of valuable established varieties is equally important, if not actually of much greater importance, to the origination of new varieties whether they arise from bud or seed variations.

In order to illustrate my point of view on the subject of the amelioration of cultivated varieties, which are commonly propagated from vegetative parts, I will try to describe very briefly some recent important work of this nature.

At the Utah Agricultural Experiment Station systematic hill selection work with potatoes has been underway since 1911. It was found that in studying the progenies of selected hills some of the progenies showed increased production as compared with the progenies of other hills or in comparison with crops grown from unselected stock. By continuing for several years the selection of the best hills in the best progenies, it has been demonstrated that the yield of the variety can be markedly increased in amount and improved in commercial quality. Therefore the culture of the variety can be made more profitable to the grower through systematic bud selection work.

In a comparative trial during 1921 of selected potato plant material with unselected stock, in Southern California, of the same variety and under similar conditions, the crop from the hills of selected plant material produced an average of 175 sacks per acre, while the crop from the unselected plant material was only an average of 35 sacks per acre Not only was the crop from the hill-selected plant material much larger than that from the unselected stock, but it was also much more uniformly valuable in size of tubers and other important commercial characteristics.

One of the largest and most successful potato growers in the United States has told me that he has increased the yield of the variety of potatoes which he cultivates more than 100 per cent through systematic hill selection work and has improved the commercial quality of the crops in like measure as a result of ten years of bud selection work.

In apples, the Agricultural Experiment Station located at Ottawa, Canada, has recently reported most interesting and important results of bud selection work. Briefly, propagations were made from three selected parent Wealthy trees. The selection of the parent trees was based upon performance records. One of the parent trees was a consistent and regular high yielder; another was a high yielder, but produced irregular crops, high yields alternating with comparatively low yields; and, the third parent tree produced consistently and regularly low yields. No differences in strain or type characteristics were or have been noticed in these three trees to my knowledge, except that the high and regular yielding parent tree showed the greatest vigor of growth and largest size.

During nine years of performance records of the progenies, originally consisting of twenty-five trees each, of the three parent trees, it has been demonstrated that the progenies have behaved almost identically the same as the parent trees. Certainly, no clearer evidence has ever been offered as to the inheritance of yield

characteristics than has been the case with this Canadian apple bud selection investigation.

In the citrus varieties grown in California my associates and I have just completed thirteen years of study of bud variations and bud selection problems. Various bulletins on this citrus fruit improvement work have been issued from time to time by the U. S. Department of Agriculture at Washington, D. C., which can be secured for study if desired.

Briefly, our investigations have revealed the fact that bud variations are common in the citrus varieties. The intentional, but more often the unintentional, propagation of these variations has led to the development of numerous strains having very different characteristics of tree growth, vegetative and fruit characteristics. Through progeny tests it has been found possible to isolate, by means of systematic bud selection work based upon adequate individual tree performance records, the different strains. In this way it has been possible to eliminate the undesirable and to propagate exclusively the desirable strains. Furthermore, in these strains it has been found possible to secure high yielding progenies from some of the highest yielding trees, and low yielding progenies from some of the low yielding trees, indicating that number or amount of fruits is a characteristic subject to bud variation and responding to bud selection in the same way that color, shape, and other fruit characteristics respond.

In our citrus work the improved production, both as regards the amount and the commercial quality of the orchards in which the trees have been grown from carefully selected buds, as compared with the yield of orchards of the same variety and under similar conditions where the trees were grown from unselected buds, amounts to more than 100 percent so far as our records go. As a result of this condition. the citrus bud selection work has been put on a commercial basis by the California Fruit Growers' Exchange, a cooperative organization of about 11,000 citrus growers, in such a way that all citrus growers and nurserymen can secure buds taken from superior parent trees of the best strains in all of the commercial varieties. This work was established in May, 1917, and up to December, 1921, had sold to nurserymen and fruit growers more than 1,650,000 selected citrus buds at the rate of five cents each. The selected buds sold to nurserymen have been generally used in the propagation of new trees, while those sold to fruit growers have ordinarily been used for top-working undesirable trees in established orchards. The charge for the buds is based upon cost and has made this public service work self-supporting from the beginning. In addition to the number of selected buds mentioned above, used in California citrus orchards, the writer and his associates distributed over 1,000,000 selected buds previous to the establishment of the bud department by the Exchange, and many growers select their own buds from superior performance record trees for top-working or other purposes.

In prunes, my associates and I have made some study of bud variation with trees of the French prune variety in California during the past three years. It has been found that the trees of this variety of deciduous fruits develop very striking bud variations. Strains of this variety, originating as bud variations exist, as in the case of the citrus, and possess very different tree and fruit characteristics.

At least one very striking variation has been found, which, if the progeny tests now under way show it to be inherently stable, will probably double the value of the crop.

In ornamental plants, many of the most commonly used plants are known to have originated from bud sports.

In flowers, many of the most important varieties have come from bud variations and have been systematically improved through bud selection work. By referring to the history of the important rose varieties as given in recent numbers of the American Rose Annual, some idea can be gained as to the importance of bud selection with cultivated flowering plants.

With several associates in the Experiment Station of the Hawaiian Sugar Planters' Association, we are now studying the improvement of sugar cane varieties through bud selection. This work is being carried on by means of progeny tests of selected stools in each of the commercially important varieties. While it is not possible to discuss in detail this work at this time, I do not hesitate to offer the opinion that through bud selection sugar cane varieties can be improved in yield of sugar per acre as much as and perhaps more than has been the case in my experience with other crops.

Methods of Work.

The methods of work in bud selection which are fundamentally important from my point of view include (1) selection of parent plants, (2) progeny tests, and (3) multiplication of valuable progenies.

In the selection of parent plants, it is first necessary to become familiar with the plant characteristics and behavior through systematic performance record studies, to develop standards for a comparative study or judging of plant characteristics, and to study the behavior of a large number of individuals under favorable cultural conditions. My experience leads me to suggest that best results can usually be expected in commercial bud selection work for the improvement of a variety of cultivated plants by securing the best fields under the best of cultural conditions for this work. An exception to this general statement should be noted in the case of efforts to secure resistance to disease, drought or other environmental factors, in which event it seems logical that the best results will be obtained by selecting parent plants for progeny tests from the fields affected by disease, drought or other condition for which resistance is desired.

As large a number of carefully selected parent plants should be used in progeny tests as it is possible to handle intelligently. In the propagation of the selected parent plants as many individuals as possible in each progeny should be grown. The number of individuals in each progeny will depend upon many factors, as, for example, the amount of propagating material available from each of the parent plants, the space available for the progeny trials, and the time and assistance which can be given to the study of the progeny behavior.

The conditions in the progeny fields (1) should be favorable to the best growth and development of the plants, (2) should be as uniform as possible in all respects, and (3) should receive the best care throughout the entire history of the progeny tests. Similar plant material should be used from each parent plant,

as, for example, slips in the case of the pineapple, although it is not important in my opinion as to whether the same number of plant pieces or buds be used in each case, and the plant material should be equally spaced and given comparatively uniform conditions throughout all of the progeny plantings.

The important fact to get in mind in this connection is that the progeny test is a method, the most efficient one with which I am familiar, of testing the stability of the inherent characteristics of the parent plants.

The progeny of each parent plant must be arranged so that it can be identified at any time. This can usually be done by driving in stakes in the plant row so as to separate the progenies. These stakes should be (1) substantial, (2) driven firmly into the soil, and (3) located where they will not be disturbed or lost during cultivation. Other methods of separating the progenies are being tried out, but the stake method, if properly used, will answer the purpose.

When the progeny plants have reached maturity, and during the course of their growth, the progeny field should be frequently studied with the greatest possible care. If some progenies are found which are comparatively uniform and desirable, the best individuals in these best progenies should be selected for progeny tests in an additional progeny field. The remaining plant material from the good plants of the best progenies can be used for commercial planting.

Suggestions for Pineapple Progeny Fields.

I have had but little opportunity for studying the pineapple. It has been my privilege to spend several days in pineapple fields when the plants were either approaching or had reached maturity in the sense that the fruits were nearly or quite ripe. In walking down the rows and observing the fruits I was greatly impressed by differences in size, shape, color, maturity, position, and other characteristics of the fruit. Similar observations as to plant behavior revealed to me wide and frequent variations in the habits of growth, leaf characteristics and size of neighboring plants in the same row. Obviously there was a large amount of variation in the plants and fruits which I observed, but whether these differences were inherent or the result of environmental influences I was unable to determine. I do not know the cause of the variations that I observed in pineapple fields and of those variations that doubtless occur in other fields. My suggestions as to the method for achieving this knowledge will be briefly stated in the following paragraphs.

In the first place we are dealing with one variety, as I understand it, the Smooth Cayenne. In the second place we are studying in the fields plants grown from vegetative plant materials. In some fields the plants may be grown from suckers, in others from slips, in others from crowns, in others from ratoon crops with one or more stages of ratooning. It would seem logical to begin this bud selection work if possible in plant fields and wherever practicable in fields where the plants have been grown exclusively from slips, or from crowns, or from suckers, as the case may be. The idea is to get away, so far as possible, from the effect, if any, of the kind of plant-material upon plant development, although I am not certain as to the importance of this factor in the case of the pineapple.

From my experience with other similar work the best fields, that is the best crops, should be selected for beginning this work unless resistance is sought which is a somewhat separate problem.

Standards of perfection, particularly in the case of the fruits, should be developed in order to make intelligent parent plant selections for progeny trials. The canners and others having well defined ideas as to the requirements for desirable fruits should be called upon for help in establishing these standards.

With regard to the fruit characteristics, the standards of perfection might include a consideration of (1) size, (2) weight, (3) shape, (4) canning quality, (5) crown, (6) maturity, (7) color, or other recognizable characteristics. Perhaps wax or wooden models of the ideal fruit which can be carried easily in the field, would be of considerable assistance for comparison with fruits observed in the field.

When fruits are found which are satisfactory the plants bearing them should be observed for several important characteristics, including the following: (1) habit of growth, (2) number of slips, (3) number of suckers, (4) vigor of growth, (5) freedom from disease, and perhaps other important considerations.

In passing it may be noted that even if the fruit is nearly perfect, if there are no slips or suckers, or an insufficient number of either, the plant would be an undesirable one for commercial purposes as a parent plant for propagation.

If satisfactory fruits and plants are discovered, and there seems to be no question but that many such exist in some fields, these plants should be marked as parent plants for progeny trials. A red cloth streamer tied to such plants will serve to identify them for this purpose.

When the slips are ready to be taken from the plants for propagation they can be secured by placing all of the slips from a single plant in a separate bag. Common paper bags may be found suitable for this purpose. The main point is to keep the slips from each selected parent plant separate. Two or three slips from each selected plant is a minimum number, and the more slips available on each plant the more reliable and valuable the progeny test will be, in my opinion.

The best of field and cultural conditions should be provided for planting the progenies. If these conditions cannot be met, the work will, in my opinion, likely prove to be unsatisfactory.

In planting the progenies enough suitable, large, stakes should be provided, one for each progeny, before planting is begun. Drive in a stake at the beginning of the first row. Plant the slips from one parent plant. Drive in a stake. Plant the slips from another parent plant. Continue this arrangement until all of the progenies are planted.

It has been found that in going from one row to another, at the ends of the rows it is usually desirable to finish a row then to cross directly to the next row and plant back, the so-called snake fashion or arrangement of planting. There are several advantages to this plan, including ease in the study of the behavior of the plants in the progenies. With this arrangement one follows a row to the end of the progeny field, crosses to the adjoining row and follows it back, and so on until all of the progenies are seen in order. It will help somewhat to paint

one side of each stake, say white, so that one can always easily follow the rows in the same order in which the progenies were planted.

During the growth of the progenies their behavior should be observed from time to time in order to gain information as to any possible progeny differences in plant growth.

When the fruits borne by the progeny plants approach maturity a most careful and systematic comparison and study should be made of the plants and fruits in each progeny, from the standpoint of uniformly good or bad or variable behavior of the plants in each progeny, and from the viewpoint of the behavior of each progeny as compared with others.

Commercially, the progenies with uniformly good fruits and plants are the ones to be considered of more than ordinary value for propagation.

The uniformly good characteristics of all of the fruits and plants within a progeny indicate to me a condition of inherent stability which is of primary and fundamental importance for the isolation of strains which will produce uniformly good crops.

Extreme variations amongst the fruits or plants in a progeny indicate to me a condition of inherent instability which is undesirable for the commercial production of the maximum number or weight of uniformly good fruits. These progenies, the inherently unstable or undesirable ones from any cause, should not be used for further commercial propagation or planting.

The progeny test will enable the grower to isolate and propagate the superior strains and to eliminate the inferior ones.

Qualifications for Successful Bud Selection Work.

May I suggest what, in my opinion, are the essential qualifications for persons engaging in this work? It is new work, pioneer effort, and for this reason, if for no other, it calls for somewhat unusual qualifications on the part of those who undertake it. There are no well defined roads to follow, so that whoever takes up this work must, in part at least, make his own road.

I can summarize the qualifications which I have in mind under three general heads, viz: (1) capacity for sustained effort, (2) intimate knowledge of the plant, and (3) ability to observe and draw correct conclusions or judge as to individual plant and progeny behavior.

The capacity for sustained effort is rare, but is absolutely essential for success in this work. Discouraging accidents, puzzling plant behavior, skeptical onlookers, and critics, and many other inevitable incidents and drawbacks will soon eliminate all those who undertake this work except those who have the capacity for sustained effort. This phase also includes a determination to find out the facts and a sympathetic point of view. It further means hard work and lots of it, concentrated effort and good physical and mental conditions.

By the term "intimate knowledge" is meant that knowledge that comes from close association with and love for the plant with which one works. The term "experience" does not cover the meaning intended, although intelligent experience is an essential part of it. One may not have this intimate knowledge in the

beginning, but one must develop it as the work progresses or it is doomed to failure.

The ability to observe and to deduce correctly from observations varies with individuals, their training and environment. It can be cultivated. Preconceived notions and prejudice must be eliminated so far as possible. The plants must be judged on their merits and as they stand.

The above statements have been directed towards those who do the actual bud selection work. I may also be permitted to suggest what I consider to be important factors of success in the work on the part of these who own or operate the pineapple plantations.

In the first place I suggest that unless it is firmly believed that this work will be of greater value than its cost, no attempt be made to undertake it. In the second place, unless it is decided to carry it out under favorable conditions, no attempt should be made to start it.

If it is believed to be fundamentally important that selected plant material be secured and that favorable conditions can be given it, I would respectfully recommend, (1) that some one having the essential qualifications for this work or who can develop them be put in charge of it; (2) that the person in charge of this work be encouraged by helpful suggestions, active personal assistance when possible or needed, and be given his entire time to it; (3) that the cooperation of all of the plantation organization be used in this work, (a helpful method of finding superior plants may be the offer of prizes for the best plants found by any of the laborers on the plantation); (4) the provision of adequate time to develop fully the possibilities of this work without interruption so far as this is humanly possible.

When superior progenies are found they should be multiplied as rapidly as possible for plantation use. All of the plant material, possibly excepting that from one or a few plants for further progeny work, can be used for this purpose so far as I am able to judge at this time. It may be possible, through new methods of propagation to multiply the valuable progenies very much more quickly than is ordinarily the case. We have now in process of trial new methods of multiplication of valuable citrus and deciduous fruit progenies which promise to increase enormously our capacity for multiplying rapidly valuable trees.

Conclusion.

In conclusion I want to thank you for your kind attention to, and consideration of my presentation of this subject. It has been inadequately done on account of my ignorance of the pineapple plant. My one hope is that I may have stimulated in some one amongst my hearers an interest in the subject which will lead to a constructive effort along this line. I shall be very glad indeed to cooperate so far as I am able in any earnest and determined study of this very important subject.

The Absorption and Interaction of Fertilizer Salts and Hawaiian Soils.

Preliminary Report.

By Guy R. Stewart.

Introduction.

When fertilizer salts are applied to the soil the farmer is primarily interested in obtaining a profitable increase to the crop he is raising. He hopes that the nitrogen, potash and phosphoric acid that he puts on the land will be directly returned to him in corn, potatoes or maybe tobacco if he happens to be on the mainland of the United States. If he is a plantation man on these islands he looks for his increase in sugar.

It was early found in the study of soil fertility that fertilization was not alone a simple problem of feeding the plant with certain nutrients. The effect of these soluble fertilizers upon the soil itself had to be considered. First and foremost there was the question of the retention of the salts within reach of the feeding roots of the crop. Justus Liebig (4) who was probably the first to consider manufacturing an artificial fertilizer tried to prevent all loss of plant food by fusing his fertilizer into an insoluble silicate. The experiment was an eminent success in locking up the fertilizer nutrients so they would not be leached from the soil, but was equally effective in preventing the plant from obtaining any of the salts. Shortly after J. T. Way (7) made the first contributions to our knowledge of the fixing power of the soil. His investigations and numerous later studies have shown us that ammonia, potash and phosphoric acid are fixed by the soil. The completeness of the fixation depends largely upon the type of soil. Detailed experiments showed that the clay fraction of the soil was the portion which principally fixed fertilizing materials though organic matter also possessed considerable absorptive power for ammonia.

Several investigations have been made upon the fixing power of our Hawaiian soils. W. T. McGeorge (5) at the Federal Station carried out a series of studies upon several typical island soils. He placed 100 grams of each soil in a series of glass tubes and determined the retention of a variety of fertilizing salts when passed through the soil in an aqueous solution. His results showed a very high fixing power for phosphates and a considerable retention of potash and ammonia. He obtained some slight evidence of the fixation of nitrates though these salts are ordinarily considered to be completely washed out of the soil.

C. F. Eckart (2) and S. S. Peck (6) of this Station have reported a series of lysimeter studies. In the first group of experiments reported by Mr. Eckart, tankage, fishscrap, hoofmeal, nitrate of soda, sulfate of ammonia and dried blood were each added to large lysimeter tubs holding 188 pounds of soil, with a depth of 14 inches of soil in the tub. Uniform applications of 16.3 grams of nitrogen in each form were made. This application would correspond to about

575 pounds of nitrogen on an acre basis. The soils were then watered at intervals and the nitric nitrogen leached out in the drainage water was determined. A later series dealt with the effect of various forms and amounts of lime upon the soil.

The efficiency of conversion of these organic forms of nitrogen into nitrates was largely judged by the amount of nitrates recovered in the drainage water. With this shallow depth of soil it was concluded that nitrogen from nitrate of soda was rapidly washed out.

Mr. Peck's experiments were reported in two series, one of which dealt with the effect of various forms of lime upon the formation of nitric nitrogen. The other considered the effect of various fertilizer salts, both alone and in combination, on the formation of nitric nitrogen, in an alkaline makai soil from a district of limited rainfall. The soils in these experiments were treated in cylinders two feet deep and eight inches wide. The fertilizer salts were added at the rate of 100 pounds each of nitrogen, potash and phosphoric acid per acre foot. The principal object of the experiment was to determine the effect of the single salts and combination of salts upon nitrification. Valuable data, however, were obtained upon the fixing power of the soils. All the phosphoric acid was completely fixed and the greater portion of the potash was also retained. There was also an appreciable retention of nitrogen from both sodium nitrate and calcium nitrate as well as from ammonium sulfate.

Beside the question of the retention of the fertilizer salts in the soil there has been a constantly increasing interest developed as to the final effect of soluble materials upon the physical, chemical, and biological condition of the soil. Several definite chemical interchanges take place immediately after a fertilizer is added. The ammonia radical of any ammonium salt is fixed in the soil while a corresponding amount of lime is freed and passes out in the drainage water along with the acid radical with which the ammonia salt was originally combined. The absorption of potash follows the same general scheme. The potash is fixed and the lime is liberated along with the chloride, sulfate or nitrate which was combined with the potash. Soluble phosphates are fixed in the soil by the calcium, iron and aluminum of the surface soil without any determinable liberation of bases.

It will be seen from the above interactions of fertilizers and soils that the direct effect of the fertilizer is to leave an appreciable amount of soluble lime salts to be washed out of the soil. With the continued application of sodium nitrate it has been found at Rothamsted that there is a tendency for the accumulation of alkaline residues in the soil, leading to the eventual formation of some sodium carbonate. This was shown by chemical examinations of the soil and by the very pasty, puddled physical condition of the sodium nitrate plots.

W. P. Kelly (3) has worked extensively in California upon the effect on citrus trees of continuous irrigation with waters of varying quality, as well as the effect of the use of sodium nitrate as a fertilizer. He has found considerable evidence of the harmful effect of salty and alkaline waters, but is not certain that the alkalinity of the soil has been increased by the sodium nitrate of itself.

Here in the Hawaiian Islands we are following a system of continuous heavy fertilization upon the cane land. On the more favorably located plantations it is customary to apply about a thousand pounds of complete fertilizer containing from 60 to 100 pounds of phosphoric acid, 100 to 120 pounds of nitrogen, and 30 to 100 pounds of potash. The second season from 75 to 150 pounds of nitrogen are applied; usually in the form of nitrate of soda. There is no present superficial evidence that this system of fertilization is producing any harmful results. In fact the writer believes that it is, on the whole, a very desirable system for the plantation to follow. It becomes important, however, for us to try to find how efficiently these nitrogen dressings, such as nitrate of soda, are retained by the soil. It is also desirable for us to know whether there is a tendency for nitrate of soda and our mixed fertilizers to produce an alkaline condition such as is indicated by the Rothamsted experiments.

Retention of Nitrogen Salts.

The work of H. P. Agee (1) and others at this Station have shown that the majority of the cane roots are located in the top two feet of soil, but part of the roots in deep soil extend down to a depth of about four feet. The retention of nitrogenous salts in four foot columns of soil was first determined. Galvanized iron cylinders four feet long and eight inches wide with a finely perforated bottom were employed in this portion of the work. The lower half of each cylinder was filled with subsoil and the upper half with surface soil.

Four soils were used:

1. A reddish calcareous soil from the Puuloa section of Honolulu Plantation.
2. A dark red manganiferous soil from the upper fields of Oahu Sugar Company.
3. A dark red soil from the mauka fields of Waialua Agricultural Company.
4. A brown silty clay loam from Waipio substation.

It will be seen that the samples included two soils that were fairly typical of many of the mauka soils on the island of Oahu. One of the makai soils, from Waipio substation, is similar to that occurring in many of the productive lower fields of Ewa and Oahu plantations. The other makai soil from Honolulu plantatiom was chosen because of its high lime content, to try to determine whether there would be a tendency for the interaction of sodium nitrate with the calcium carbonate of the soil to form sodium carbonate.

The nitrogenous salts employed were ammonium sulfate, sodium nitrate and ammonium nitrate. Each of these was added in chemically equivalent amounts so as to add nitrogen at the rate of 155 pounds of nitrogen to the surface foot, equivalent to an application of 1000 pounds of nitrate of soda per acre.

The salts were applied and a two and one-half inch irrigation with tap water was first made. This water contained a moderate concentration of total salts. The loss of ammonia, nitrates and nitrites in the drainage water was then determined. Following this three more irrigations were given at two week intervals, one with two and one-half inches of water and a third and fourth with five inches.

Under field conditions the plant rapidly absorbs the nitrogenous dressings. The purpose of the experiment here was to find the amount of nitrogen that would be lost in a moderate number of irrigations, before the plant would probably have a chance to absorb all the fertilizer. This would also be comparable to the effect of several moderately heavy rains on unirrigated plantations.

Upon analysis of the solutions that percolated through the soil it was found that there were no appreciable amounts of ammonia or nitrites leached out from either the treated or untreated soils. Small traces were present in all the solutions. The nitrogen was not removed from the soil in significant amounts until it was converted over to nitrates. This is clearly shown by the analytical results in Table I. There was practically no added nitrogen removed from the ammonium sulfate treatments by the first and second irrigations. Then the formation of nitrates began to be appreciable and nitrates were removed by the last two irrigations. The results show that it is comparatively safe to use any of the three forms of nitrogen salts upon the Island soils.

The retention of nitrates will vary with the type of soils, but with soils of average depth we may be reasonably sure that the greater part of a nitrate application either as nitrate of soda or ammonium nitrate will not be washed out by any ordinary rain, or the usual irrigations, before the cane has a chance to absorb it.

TABLE I

LOSS OF NITROGENOUS FERTILIZERS FROM FOUR-FOOT SOIL COLUMNS

Results Expressed in Milligrams of Nitrogen

Number of Irrigation	Amt. of Irrigation	Honolulu Plantation Red Calcareous Soil: Blank	Ammon. Sulfate	Sod. Nitrate	Ammon. Nitr.	Oahu Sugar Company Red Mauka Soil: Blank	Ammon. Sulfate	Sod. Nitr.	Ammon. Nitr.
1	2.5 in.	38.7	40.2	49.2	51.1	89.7	90.5	92.4	103.0
2	2.5 in.	22.5	25.2	11.1	28.6	41.7	45.2	69.0	51.6
3	5.0 in.	158.3	165.2	160.7	164.2	194.4	210.2	229.0	234.0
4	5.0 in.	713.0	890.0	467.0	868.0	464.0	575.0	583.0	504.0
Total loss		932.5	1,120.6	688.0	1,111.9	789.8	920.9	973.4	892.6
		.....	932.5	932.5	932.5	.....	789.8	789.8	789.8
Net loss		.....	188.1	0.0	179.4	.....	131.1	183.6	102.8
Nitrogen added..		.....	563	563.0	563	.....	563	563 0	563
Per cent lost		.....	33.4	.....	31.8	.....	23.3	32.6	18.2

Number of Irrigation	Amt. of Irrigation	WAIALUA AGRICULTURE CO. Red Mauka Soil				WAIPIO SUBSTATION Brown Clay Loam			
		Blank	Ammon. Sulfate	Sod. Nitrate	Ammon. Nitr.	Blank	Ammon. Sulfate	Sod. Nitrate	Ammon. Nitrate
1	2.5 in.	140.0	142.0	173.0	151.0	35.9	36.6	53.0	66.7
2	2.5 in.	63.8	65.2	66.9	67.3	26.7	28.2	40.9	26.9
3	5.0 in.	266.8	301.0	322.7	311.5	124.3	155.0	186.8	175.5
4	5.0 in.	584.0	702.0	691.0	569.0	456.0	523.0	513.0	451.0
Total loss		1,054.6	1,210.2	1,253.6	1,088.8	642.9	742.8	793.7	720.1
		......	1,054.6	1,054.6	1,054.6	.....	642.9	642.9	642.9
Net loss		......	155.6	199.0	34.2	.....	100.9	150.8	87.2
Nitrogen added..		......	563.0	563.0	563.0	.....	563	563	563.0
Per cent lost		......	27.6	35.3	6.0	.....	17.9	26.8	15.5

Localization of Nitrogenous Applications.

It is of decided interest to know just where the various nitrogenous salts tend to be held in the soil after a heavy rain or irrigation. We have seen that only a moderate part of any of the three under investigation is actually carried out of the soil. This does not, however, show just where the greater part of the salt will be held. The same applications of each salt, that is to say 563 milligrams of nitrogen. representing a fertilization of 155 pounds per acre, were added to cylinders of the same soils. One five-inch irrigation with tap water was made and the percolate analyzed as before. Less than five per cent. of nitrogen from nitrate of soda or ammonium nitrate was carried out of the soils and none of the nitrogen from the ammonium sulfate.

The soil was now removed from each cylinder in one foot sections and in the ammonium sulfate cylinders the top six inches was also analyzed separately. Samples of each section of soil were now shaken with distilled water; and ammonia, nitrites and nitrates determined in the water extracts. The analysis of these extracts and of those from the soils treated with mixed fertilizers was made by F. Hansson of the Chemistry Department. The analytical results are given in Table II. The results for ammonia nitrogen clearly show that with the high fixing power of the Island soils, it has not been possible to extract more than a portion of the ammonia compounds present. The figures do show, however, that the ammonia of the ammonium sulfate and nitrate was fixed in the top foot of soil. The nitrate of both the nitrate of soda and ammonium nitrate was held in general in largest amounts in the second, third and fourth foot. It was still within the feeding zone of the cane plant and would undoubtedly tend to be carried back towards the first foot by the rise of capillary moisture.

TABLE II

LOCALIZATION OF NITROGENOUS SALTS IN FOUR-FOOT COLUMNS

Soil	Ammonium Sulfate Parts per Million Dry Soil			Sodium Nitrate Parts per Million Dry Soil			Ammnium Nitrate Parts per Million Dry Soil		
	Ammonia Nitrogen	Nitrite Nitrogen	Nitrate Nitrogen	Ammonia Nitrogen	Nitrite Nitrogen	Nitrate Nitrogen	Ammonia Nitrogen	Nitrite Nitrogen	Nitrate Nitrogen
Honolulu Plantation									
1st 6 in...	12.2	1.02	23.0	7.7	0.02	8.1	5.9	0.69	20.7
2nd 6 in..	8.0	0.02	15.0						
2nd foot..	6.2	0.01	46.8	8.0	0.01	71.6	4.0	0.02	111.2
3rd foot..	4.1	0.01	101.1	4.0	0.02	104.1	4.1	0.02	136.2
4th foot..	2.2	0.01	35.0	3.3	0.02	116.4	4.2	0.01	163.9
Oahu Soil									
1st 6 in...	19.3	0.17	146.5	1.5	0.02	24.2	9.5	0.04	26.7
2nd 6 in..	4.0	0.01	30.0						
2nd foot..	2.1	0.01	88.0	1.5	0.02	95.6	3.9	0.01	143.5
3rd foot..	2.0	0.01	79.3	1.2	0.01	85.7	1.9	0.01	100.6
4th foot..	1.0	0.01	121.8	1.1	0.01	90.6	2.0	0.01	131.9
Waialua									
1st 6 in...	20.5	0.03	16.4	1.3	0.01	28.4	10.4	0.02	15.6
2nd 6 in..	5.2	0.01	13.6						
2nd foot..	2.2	0.01	48.1	1.7	0.02	115.2	5.3	0.01	39.3
3rd foot..	2.1	0.01	106.7	1.2	0.01	109.0	2.1	0.01	162.7
4th foot..	2.1	0.02	170.7	0.8	0.01	125.3	2.2	0.01	187.3
Waipio									
1st 6 in...	8.9	0.62	19.5	4.1	0.02	39.4	2.6	0.05	28.0
2nd 6 in..	3.6	0.09	22.3						
2nd foot..	9.1	0.03	32.0	4.2	0.01	46.5	2.7	0.01	52.2
3rd foot..	3.7	0.01	29.9	1.2	0.01	50.4	1.8	0.02	47.7
4th foot..	3.8	0.01	37.7	1.0	0.01	33.2	2.8	0.1	43.8

Interaction of Soils and Nitrogenous Salts.

The next study undertaken was the determination of the solubility effect of the three nitrogenous salts upon the same four soils. The salts were added to half-gallon jars of soil which was at the optimum moisture content. The mixture was allowed to stand about three days to give time for the first effects of solution to take place. Portions of the soil were then extracted with water and analyzed for ammonia, nitrates, nitrites, potash, calcium, magnesium, phosphates and total solids. The results are given in Table III and are compared with a similar analysis of the untreated soil.

The detailed results show a number of interesting facts. The same discrepancy between the ammonia salts added and the amount recovered by extraction in water is clearly evident. There is a fairly close agreement for the nitrates found and known to be present. All the salts show a definite solubility effect upon the soil minerals. It is generally considered that sodium nitrate releases the soil potash when it is applied as a fertilizer. There is no evidence that it has done this with the four soils that have been used. In all cases, the

TABLE III

INTERACTION OF NITROGENOUS SALTS AND SOILS

Results Expressed in Parts per Million Dry Soil

Soil	Treatment	Reaction Ph	Ammonia N	Nitrite N	Nitrate N	Potash K_2O	Lime CaO	Magnesium Mgo	Phosphate P_2O_5	Total Solids	Volatile Solids	Non Vol. Solids
Honolulu	Blank	8.5	4.4	4.9	13.8	86	149	85	22	1,343	356	987
"	Sod. Nitrate ..	8.5	4.4	4.9	72.6	76	180	92	22	1,706	378	1,329
"	Am. Nitrate ..	8.5	5.8	4.9	46.5	131	153	90	30	1,575	399	1,176
"	Am. Sulfate ..	8.4	8.7	4.9	16.7	113	175	92	27	1,699	515	1,183
Oahu Plant...	Blank	7.7	4.3	0.05	7.8	49	33	30	1.9	399	200	199
" " ...	Sod. Nitrate ..	8.0	5.7	0.10	67.7	40	52	34	2.0	919	328	591
" " ...	Am. Nitrate ..	8.1	7.8	0.05	41.3	86	50	25	1.9	656	214	442
" " ...	Am. Sulfate ..	7.2	17.1	0.10	7.8	79	62	31	1.8	748	214	534
Waialua	Blank	7.9	6.9	0.25	28.9	49	53	32	2.0	647	304	343
"	Sod. Nitrate ..	8.0	7.6	0.20	87.5	35	100	47	1.5	1,180	327	852
"	Am. Nitrate ..	8.1	18.3	0.20	60.9	54	78	40	1.7	982	426	556
"	Am. Sulfate ..	7.4	30.4	0.20	30.4	79	69	39	1.5	936	327	609
Waipio	Blank	7.7	°.7	0.15	4.1	62	19	12	2.4	452	144	408
"	Sod. Nitrate ..	8.0	2.7	0.35	63.7	48	29	27	2.5	945	301	644
"	Am. Nitrate ..	8.0	4.8	0.35	34.2	52	26	25	2.3	719	281	438
"	Am. Sulfate ..	7.5	13.7	0.20	4.1	64	36	36	3.2	801	199	602

potash is lower in the sodium nitrate treatment than in the untreated soil. The ammonium nitrate and ammonium sulfate do show this influence on most of the soils. All the salts tend to release calcium and magnesium, so it is evident that all these materials exert a solubility effect on the soil, but it is greatest with the two ammonia salts.

The effect of all these salts has been determined upon the reaction of the soil. An exact electrical method has recently been developed for measuring the reaction of soils and other materials in solution. By reaction in this sense is meant the intensity of acidity or alkalinity instead of the total amount present. Extended investigations have shown that it is this intensity factor which is most important to plants and animals. It is usual to express this intensity of reaction on a numerical scale upon which the neutral point, equivalent to the reaction of pure water, is given as Ph 7.0. Numbers less than 7.0 denote greater acidity, while larger numbers show a more alkaline reaction.

In the column headed "Reaction Ph" it will be seen that the Honolulu Plantation soil has a reaction of Ph 8.5. This soil contains over 5.5% of lime as CaO, and this reaction indicates that the soil is completely saturated with lime. The addition of the sodium nitrate and ammonium nitrate did not effect the reaction, while the ammonium sulfate has had its well known effect of causing the soil to change faintly towards the acid side. With the other soils the ammonium sulfate developed a faint degree of acidity and the other two salts caused a slight change towards alkalinity. The effect of this change of reaction would have to be studied in the presence of crops before one could state that it was likely to be in any way harmful. It is known that the sodium nitrate leaves a residue of the sodium ion, or radical, in the soil, while with the ammonium nitrate both radicals are absorbed so the soil should later return to its former reaction.

Interaction of Soils and Mixed Fertilizers.

The immediate solubility effect of two mixed fertilizers was next determined. Fertilizer No. 1 was a phosphate and nitrogen mixture similar to that used by several plantations. It contained 10% P_2O_5 and 8% total nitrogen equally divided into 4% ammonia nitrogen and 4% nitrate nitrogen. Fertilizer No. 2 was a complete mixture containing 6% total P_2O_5, 11% total nitrogen subdivided into ammonia nitrogen 4%, nitrate nitrogen 6%, and organic nitrogen 1%. It also contained 6% K_2O.

These two fertilizers were added to half-gallon jars of soil at the rate of 1000 pounds per acre foot of soil. The determinations of water soluble nutrients and the change in reaction are given in Table IV. It is interesting to note that though fertilizer No. 1 contains no water soluble potash, there has been an increase in this material, owing to the solubility effect of the nitrogen mixture. Both this fertilizer and fertilizer No. 2 show an appreciable effect of solution on the other soil materials as evidenced by the increase in calcium, magnesium, and total solids. Each of the mixtures showed a slight increase in alkaline reaction on most of the soils. It is planned to analyze these mixtures of fertilizer and soil after the lapse of several months.

TABLE IV
INTERACTION OF MIXED FERTILIZERS AND SOILS
Results Expressed in Parts per Million Dry Soil

Soil	Treatment	Reaction Ph	Ammonia N	Nitrite N	Nitrate N	Potash K_2O	Lime CaO	Magnesia MgO	Phosphate P_2O_5	Total Solids	Volatile Solids	Non Volatile Solids
Honolulu	Blank	8.5	4.4	4.9	13.8	86	149	85	22.0	1,343	356	987
"	Fert. No. 1 ...	8.6	0.2	0.14	72.6	123	178	129	22.1	1,888	327	1,561
"	Fert. No. 2 ...	8.7	0.3	0.30	72.6	121	208	121	20.8	1,851	327	1,524
Oahu Sugar Co.	Blank	7.7	4.3	0.05	7.8	49	33	30	1.9	399	200	199
" " "	Fert. No. 1 ...	8.3	14.2	0.25	28.5	92	42	39	2.2	713	143	570
" " "	Fert. No. 2 ...	8.7	11.4	0.14	44.2	81	37	40	2.6	784	142	642
Waialua	Blank	7.9	6.9	0.25	28.9	49	53	32	2.0	647	304	343
"	Fert. No. 1 ...	8.2	30.4	0.19	63.9	72	74	50	3.7	1,066	342	724
"	Fert. No. 2 ...	8.6	27.4	0.15	65.4	66	74	39	3.1	913	228	685
Waipio	Blank	7.7	2.7	0.15	4.1	62	19	12	2.4	452	144	408
"	Fert. No. 1 ...	7.7	0.4	0.13	28.7	53	31	48	2.1	856	240	616
"	Fert. No. 2 ...	8.2	0.4	0.26	20.5	56	26	43	2.8	719	205	514

Summary.

1. The retention of ammonium sulfate, sodium nitrate and ammonium nitrate was determined in four-foot soil columns of Hawaiian soils of distinctive types.

2. Ammonium sulfate was perfectly retained until nitrification took place.

3. Four irrigations, two of which were heavy, removed from six per cent to thirty-five per cent of the added nitrogen dressings.

4. The ammonia radical was found to be fixed in the top foot of soil.

5. The nitrates were largely washed down into the second, third and fourth foot of soil by one heavy irrigation of approximately six inches of water.

6. All the nitrogen salts showed some solubility effect on the soil minerals. There was more effect from ammonium nitrate and ammonium sulfate in rendering plant food soluble than there was with sodium nitrate.

7. Sodium nitrate and ammonium nitrate caused a slight increase in the alkaline reaction of most of the soils used. Ammonium sulfate showed the usual slight increase in acidity.

8. Mixed fertilizers added to the soil also caused a slight increase in the alkaline reaction of the soil and some effect of secondary solubility on the soil minerals.

9. It is planned to extend these studies to field soils and cultures with sugar cane before trying to apply them to field practice.

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Recovery of Sugar from Last Mill Juice.

By W. R. McAllep

With the increase in the amount of sugar extracted from cane, resulting from the improved mill work of recent years, the question has been brought up frequently: How much of the extra sugar extracted is finally obtained in the form of commercial sugar? The two principle factors involved in answering this question are: Is increased extraction accompanied by an increased deterioration of sugar in the mill, and what is the value of the last extracted juice?

With respect to the first of these factors there is no doubt but that some loss through bacterial action always takes place and that compound maceration increases the length of time juices are exposed to such action. Investigation by H. S. Walker [1] at Pioneer Mill Company, and by the writer at several other factories, has shown that, at least when sound cane is ground, the rate of deterioration is slow enough so that the loss is negligible during the time necessary to complete the milling cycle. Deterioration can and does take place in any material that is allowed to accumulate in the mill, juice strainers, etc., thus taking longer than the normal time to complete the cycle. High extraction does not necessarily increase such losses. Observation has given the writer the impression that more often than not the care necessary to secure the high extraction results in cleaner conditions around the mill than when mediocre results are obtained.

The second factor, the value of the last mill juice, depends on the increase in purity during clarification and on the molasses forming action of the remaining impurities. The purity of the last extracted juice is considerable lower than the purity of the juices extracted at preceding mills and the difference is accentuated with increasing extraction. Doubts have frequently been expressed as to whether the molasses resulting from last mill juice could be reduced to as low a purity as that from the previously extracted juices, and sometimes even whether sugar could actually be made from it at all. These opinions have been based largely on the fact that the proportion of glucose decreases and the proportion of ash increases in the last extracted juices. While there is but little reliable information regarding the molasses forming properties of the different impurities, these opinions are not entirely without foundation for glucose does render it easier to secure lower purity molasses, though undue importance is frequently given this factor. Analysis of available figures for Hawaiian mills, however, does not support these views. Horace Johnson,[2] quoting figures for extraction and recovery extending over a period of several years, concludes: "These results show that not only the sugar due to increased extraction was recovered, but that the quality of the boiling house work has also shown decided improvements."

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[1] Record, Vol. XXIV, page 202.

[2] Report of Committee on Manufacture of Sugar. H. S. P. A. 1918.

While the figures indicate that the expected amount of sugar has been recovered from the last increment of extraction, so far as the writer is aware, this has never been experimentally demonstrated previous to the work herein described. During the latter part of the season of *1921*, the writer, assisted by H. F. Bomonti and W. L. McCleery, at the request and with the cooperation of Kahuku Plantation Company, made a study of the crystallization of sugar from last mill juice resulting from very low purity cane. The last mill juice was clarified, evaporated, boiled to a massecuite and the massecuite dried in experimental apparatus, available through the courtesy of this plantation. The work was done under careful chemical control, the analyses including all determinations that seemed of probable value in interpreting the results.

Preliminary clarification studies were made on a laboratory scale, by Mr. Bomonti. It was found that a satisfactory clarification, resulting in comparatively clear, well settled juices could be obtained. The desirable reaction corresponded closely to that of most juices. This is a point from one-half to three-quarters of the way from the neutral point to litmus to the neutral point of phenolphthalein. In these last mill juices it was at an alkalinity to litmus of approximately .012 (% CaO). As is usually the case, it could be approximated by liming the cold juice to the neutral point to phenolphthalein. The presence or absence of cushcush was found to be a material factor in the possible increase in purity. The last mill juice after passing the mill screens contained from 0.7% to 0.8% of suspended solids. This amounted in these dilute juices to between 20% and 25% of the polarization, a much larger ratio than in mixed juice where it ordinarily is between a minimum of 2% and a maximum of 7%. Passing the juice through 100 mesh screen reduced the suspended solids to between .12% and .16% and caused an apparent increase in purity of about 3.5. As no soluble solids had been removed by this screening the increase in purity was apparent only. In reality the purity as ordinarily determined was too low because of the effect of the suspended matter on the brix determination. Removing the coarser of the suspended matter before the addition of lime resulted in a total increase of apparent purity from 2 to 5 points greater than when the screening was done subsequent to clarification. This preliminary work demonstrated that a much greater increase in purity than anticipated, amounting to from 7 to 10 points over the apparent purity of the last mill juice, could be secured after a preliminary screening and a properly conducted clarification with lime.

Last mill juices were clarified and evaporated to syrup on November 9, 10 and 11. The quality of the cane ground at Kahuku on these days and the extraction and dilution are shown in the following tabulation of figures taken from the Kahuku laboratory records:

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Last mill juices were clarified and evaporated to syrup on November 9, 10 and 11. The quality of the cane ground at Kahuku on these days and the extraction and dilution are shown in the following tabulation of figures taken from the Kahuku laboratory records:

TABLE 1.

	Nov. 9	Nov. 10	Nov. 11
Purity First Mill Juice ..	72.40	77.88	78.89
Purity Last Mill Juice ...	58.30	65.60	64.20
Dilution	11.52	8.28	8.26
Extraction	93.75	94.23	94.13

While none of the cane was of particularly good quality it varied considerably. The first mill juice from some of it was above 80 while in extreme cases it was below 60 in purity.

The milling equipment at Kahuku consists of a three roller crusher, a Searby shredder and a nine roller mill 34″ x 72″. It had been intended to utilize the third mill juice resulting from the poorest cane ground, using from 30% to 35% maceration. The macertion was increased while juice for the first two runs was being taken. The desired point, however, was not very closely approximated, the maceration being 20% during the first and 55% during the second run. One cell of the evaporators was being repaired and the full capacity of the remaining equipment was required to evaporate the amount of juice received from the mill with the 8% to 10% maceration then being carried. The increased maceration during runs 1 and 2 caused delays in the factory operations; it also became evident that the experimental pan used as an evaporater was not of sufficient capacity to produce the minimum amount of syrup required for a massecuite from juices as dilute as two or three brix, during the time available for this experiment. For these reasons the maceration was not changed from the amount regularly carried when withdrawing juice for the remaining four runs. While the greater part of the juice used in this experiment resulted from comparatively low maceration, conditions with respect to purity were as severe as could be desired. The average apparent purity of the juice taken was 49.9. According to the Kahuku laboratory records the corresponding purity of the first mill juice was 67.2.

The juice was clarified in old massecuite cooler cars of 90 gallons capacity, fitted with cocks for drawing off the settled juice. A portable steam coil made of 3/4″ pipe was used for heating the juice. This coil was immersed in the car, the contents of which were to be heated. Suspended solids in the last mill juice averaged .66%. The juice was passed through a 100 mesh screen previous to clarification, reducing the suspended solids to .20% and increasing the apparent purity from 49.9 to 53.3. After this screening the suspended solids were 6% of the polarization. The screened juice was limed to a slight alkalinity to phenolphthalein, boiled and allowed to settle. With the exception of run number 4, the results were satisfactory. The clarification was good, the settling rapid and the average alkalinity was close to .012. The alkalinity was higher than was desirable in run number 4. Though the total increase in purity in this run was satisfactory, the increase due to lime was smaller, the settled juice was not clear, and there was a tendency to foam during evaporation.

An experimental pan of about 35 gallons capacity, was used for evaporating and boiling. Vacuum obtained was rather low, seldom exceeding 24″. Between 15 and 25 gallons of juice per hour could be evaporated, though above the former rate entrainment became heavy. Between 15% and 30% of the solids taken into the pan during this experiment was lost through entrainment. Clear, settled juices only were evaporated, no attempt being made to save the settlings. The syrup from run number 2 was discarded. Difficulties with the pan caused a considerable delay during this run and a quantity of clarified juice that had cooled off and deteriorated badly was drawn into the pan before the deterioration was discovered. The syrup was evaporated to between 70 and 75 brix. At this density there was no detectable deterioration, though some of it was held for three days before boiling without the use of preservatives. The syrup was not very clean for though the settling, except in run number 4, was good, evaporation of from 90% to 96% resulted in the suspended matter being concentrated to a very small volume. The reaction was destinctly alkaline to litmus. Approximately 20 gallons of syrup were obtained from five runs. Apparent purities for the different runs are given in detail in the following tabulation. First mill juice figures are from the Kahuku laboratory records. Run number 2 is omitted from the averages.

TABLE 2.

Run No.	Variety	Purity First Mill Juice	Last Mill Juice			Clarified Juice	Syrup	Increase in Purity
			Brix	Purity	After Screening			
1	Y. C.	65.6	3.07	44.0	48.5	58.1	57.9	13.9
2	?	55.5	2.47	50.2	57.1	63.8	46.2	—4.0
3	Y. C.	61.4	8.16	47.2	48.6	54.8	55.2	8.0
4	?	70.1	6.26	49.2	54.9	56.9	58.7	9.5
5	Y. C.	67.6	5.91	47.5	51.8	54.2	55.9	8.4
6	Y. C.	72.9	5.91	59.6	62.5	64.5	65.8	6.2
True average		67.2	6.20	49.9	53.3	57.2	58.6	8.7

It will be noted that screening caused an increase of 3.4 in purity; clarification a further increase of 3.9 and there was an increase of 1.4 during evaporation, making a total increase in apparent purity from the last mill juice to syrup 8.7.

The syrup was boiled to a massecuite on November 12. A good grain was readily obtained by thickening half of the syrup to "string proof" and letting it stand a few hours in the pan. A circulating baffle in the pan prevented starting this graining charge to boiling again, and it was necessary to draw in the whole of the syrup. Most of the original grain melted during this manipulation rendering it necessary to bring in a secondary grain that could not be built up to a desirable size for want of material. The massecuite was boiled slowly for several hours to reduce the mother liquor to as low a purity as possible. Some 10 gallons of massecuite of 96 brix, 58.0 apparent and 60.4 gravity purity were

The sugar was 76.3 apparent and 78.6 gravity purity. Securing a sugar dried to this purity under conditions approximating factory practice from a massecuite containing so much false grain and in which the mother liquor was reduced to thirty-four gravity purity was a somewhat better result than could reasonably have been expected.

Averages of the analyses made during this work appear in accompanying tabulation. The figures for ash and glucose in the juice are not, however, directly comparable with the corresponding figures for syrup, for in runs 1 and 2 these determinations in the juices were lost. In order that comparison involving the use of ash and glucose content may be made, figures for runs 4, 5 and 6, which are comparable, are tabulated below:

TABLE 6.

	Brix	Sucrose	Gravity Purity	Glucose	Ash	Glucose / Ash	Sucrose / Ash
Screened juice	5.71	3.24	56.7	0.75	0.27	2.77	12.0
Clarified juice	5.55	3.27	59.0	0.75	0.32	2.33	10.2
Syrup	73.18	45.01	61.37	10.60	4.02	2.64	11.2

The molasses secured from this experiment was submitted to the same treatment that has been used in studying other samples of molasses at this Station. This consists of concentrating, seeding with fine grained sugar and, after crystallizing in motion under carefully controlled temperature conditions, separating the mother liquor. The tabulated results follow:

TABLE 7.

	Molasses	Concentrated Molasses	Check	Final Molasses
Brix	88.2	96.7	95.4	93.65
Sucrose	32.40	35.94	35.52	26.01
Gravity Purity	36.74	37.17	37.23	27.77
Total Solids	79.89	87.02	87.03	83.87
True Purity	40.56	41.30	40.81	31.01
Glucose	20.78	21.51	20.49	22.77
Ash	8.79	9.55	10.04	10.99
Org. Non-Sugar	17.92	20.02	20.98	24.10
Sucrose: Ash	3.69	3.76	3.54	2.37
Glucose: Ash	2.36	2.25	2.04	2.07
O. N. S.: Ash	2.04	2.10	2.09	2.19
Water	20.11	12.98	12.97	16.13
Sucrose: Water	1.61	2.77	2.74	1.61

The first column is the analysis of the molasses before treatment, the second after concentration, the third the unseeded sample placed in the crystallizer to detect changes during crystallization and the last column the analysis of the molasses separated from the seeded and crystallized massecuite.

The results do not differ in any material respect from those of a number of other samples that have been similarly treated. There was no destruction of sucrose during boiling, but the usual small destruction of sucrose during crystallization may be noted. There was also the usual small destruction of glucose during boiling and a somewhat greater than the average destruction of glucose during crystallization. The gravity purity was reduced to 27.77, a figure within some two points of as low as any samples of Hawaiian molasses which have been reduced by this method. Judged by the above figures this molasses can hardly be classed as abnormal for all the characteristics shown lie within the limits of other samples of Hawaiian molasses that have been similarly treated.

The work done at the Kahuku factory developed the following points. The actual purity of the last mill juice was higher than indicated by the ordinary analysis because of the effect of the suspended matter on the brix. The total increase in purity obtained by screening and clarification was very large. In the more dilute juices in runs 1 and 2 the increase was from 50% to 100% greater than in the more concentrated juices in later runs. The larger increase in purity in the more dilute juices seems to be due both to the relatively greater effect of the suspended solids on the brix and a greater removal of soluble impurities. Figures for runs 4, 5 and 6 indicate a small increase in ash during clarification and a small decrease during evaporation. Glucose remained unchanged during clarification, increased slightly during evaporation, and decreased during both boiling and crystallization. The differences noted between clarified juice and syrup, however, may be considered within the limits of experimental error when the large differences in the concentration of the samples analyzed are taken into consideration. With the exception of the small increase in glucose during evaporation, which as just noted is hardly beyond the limits of experimental error, none of the figures gives any indication that any material amount of sucrose has been destroyed. In particular the analysis of a portion of the massecuite on December 23, demonstrates that the reduction in the purity of the molasses was due to crystallization of sucrose and that no loss had occurred while the massecuite was maturing. The loss of sucrose in run number 2 is not taken into consideration in making the above comments. The conditions which caused this loss were accidental and would not ordinarily be encountered in well conducted factory operations. This experiment demonstrated that with well conducted factory work a much larger yield of sugar could be obtained from the last mill juice than would be inferred from its purity, for even though final molasses of normal purity were assumed, an increase of over 10 points between the apparent purity of the raw juice and the gravity purity of the massecuite would hardly be expected. Assuming commercial sugar of 98 gravity purity, no losses in manufacture, and reduction of the molasses to 33.8 gravity purity, the S. J. M. formula indicates a yield of 67% of the sucrose in

this last mill juice, originally of 49.9 apparent purity. Further, the work at this Station failed to develop any particularly abnormal characteristics in the molasses.

In estimating the value of the last mill juice from the results of this experiment there is some question as to whether or not the removal of a part of the cushcush before clarification is the equivalent of present milling practice. No data is available as to whether a considerable part of the cushcush is removed when the last mill juice is used as maceration and rescreened or whether the cushcush is carried on into the mixed juice. Undoubtedly more or less of a screening action does take place when the juice is applied as maceration and, in the writer's opinion, screening juice before clarification makes the results of the experiment more nearly comparable to the results actually secured in factory practice, than would have been the case had the cushcush been removed subsequent to clarification. Had the latter course been adopted this experiment would have been to a considerable extent a study of the effect of organic impurities dissolved through the action of lime and heat instead of a study of the effect of the soluble impurities in the last mill juice. In this connection, it should be noted that present screening practice leaves much to be desired. With an improvement in screening practice any discrepancy between the results of this experiment and factory practice would be removed.

This experiment was conducted under decidedly abnormal conditions so far as the quality of the cane was concerned, and the results must be used with a considerable degree of caution in estimating the value of last mill juice under normal conditions. According to all present information when cane of good quality is ground, the glucose content of last mill juice is lower than was the case during this experiment. While data at this Station indicates that undue importance is often given the role played by glucose in the formation of molasses, it is undoubtedly easier to reduce the final molasses resulting from last mill juice, high in glucose, to a low purity than it is in the case of juices of lower glucose content. To just what extent the lower glucose content will affect the results can only be determined by experiment and it is planned to repeat the experiment at an early date using last mill juice resulting from normal cane and higher extraction.

Nitrogen Increases Yield at Grove Farm.

GROVE FARM EXPERIMENTS 2, 3, 4, AND 5, 1922 CROP.

By J. H. Midkiff.

Summary.

These experiments, covering a period of six years and consisting of three crops, plant cane, first, and second ratoons, deal with nitrogen applications. Amounts to apply, the time of application and forms of nitrogen have been studied. The results of the plant cane experiments were printed in *The Record*, Volume XIX, page 270, and the results of the first ratoon trials were printed in Volume XXII, page 307.

The cane was D 1135, the 1922 crop being the second ratoons. The previous crop was harvested in April, 1920. It was cut back in July. Although the experiment schedule called for four applications of fertilizer, two the first season and two in the second, only two applications were made in all (with the exception of Experiments 3 and 4, dealing with the time of application). One application was made in October 1920, and the other three combined in March 1921. The cane in all plots received a uniform dose of 500 pounds reverted phosphate per acre.

The results of the different treatments follow:

Experiment 2. Amount to Apply.

Plots	Treatment	Yield per Acre			Gain Over No Fertilizer	
		Cane	Q. R.	Sugar	Cane	Sugar
X	No fertilizer	27.66	7.55	3.66	....	....
A	1000 lbs. nitrogen mixture	35.69	7.93	4.50	8.03	0.84
B	2000 lbs. nitrogen mixture	35.03	7.87	4.45	7.37	0.79

Experiment 3. Time of Application.

Plots	Treatment	Cane	Q. R.	Sugar
A	1000 lbs. nitrogen mixture in three doses, 250 lbs. in October, 500 lbs. in March and 250 lbs. in June..	39.51	8.15	4.85
C	1000 lbs. nitrogen mixture in two equal doses second season, March and June. No fertilizer first season	35.98	7.87	4.57
D	1000 lbs. nitrogen in two equal doses: one in October first season and one in March second season	34.94	7.54	4.63

Experiment 4. Amount to Apply Second Season.

Plots	Treatment	Cane	Q. R.	Sugar
C	1000 lbs. nitrogen mixture applied in one dose in March	37.59	7.77	4.84
E	500 lbs. nitrogen mixture applied in one dose in March	37.92	7.44	5.10

Experiment 5. Forms of Nitrogen.

Plots	Treatment	Cane	Q. R.	Sugar
A	1000 lbs. nitrogen mixture, 250 lbs. in October and 750 lbs. in March, 1921	35.1	8.14	4.31
F	1000 lbs. nitrogen mixture applied in one dose in October, 1920	35.86	8.41	4.26
G	1250 lbs. dried blood, 12% nitrogen, applied in one dose, October, 1920	35.02	8.96	3.91

The harvesting results of Experiment 2 show that 150 pounds of nitrogen gave an increase of over eight tons of cane and .84 ton of sugar per acre over no nitrogen. In the first ratoon 177 pounds of nitrogen gave an increase of .70 ton of sugar over 27 pounds of nitrogen. There was an increase of only .10 of a ton of sugar from the application of 150 pounds of nitrogen in the plant cane. While the addition of 150 pounds of nitrogen increased the sugar yield only 1.3 percent in the plant cane, it increased it 13 percent in the first ratoon and 23 percent in the second ratoon.

In the plant cane and both the ratoon crops, 300 pounds of nitrogen gave slightly less than 150 pounds of sugar per acre. This was due to the fact that the heavier dose of nitrogen lowered the purity of the juices, as the weight of the cane in the 150 pound and the 300 pound plots was practically the same in all cases.

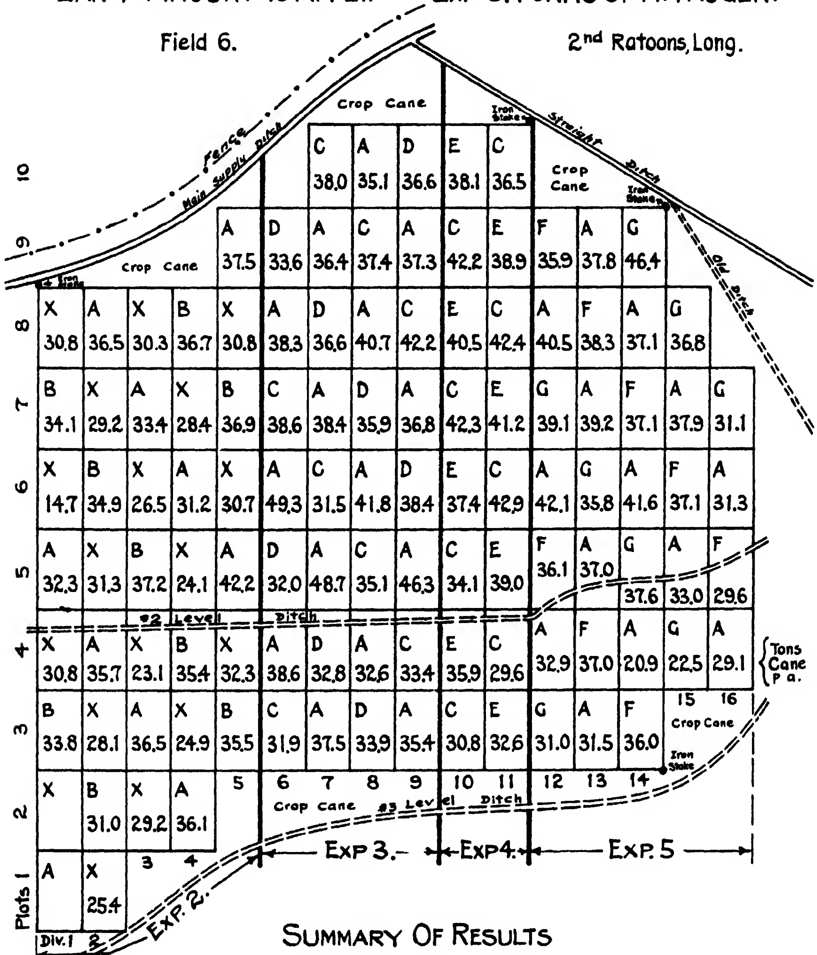
A study of the results of Experiment 3 for the three crops does not prove conclusively the proper time of applying nitrogen. In the plant crop the cane in all plots was of practically the same weight. But the heavy doses the second season caused the juices of the C plots to be poorer and caused a resulting decrease in sugar. In the first ratoon the juice from the C plots which received all their fertilizer the second season was as good as that of the D plots which received all their fertilizer the first season. And in this case the C plots, having more cane, produced more sugar. In the second ratoons the A plots received one-fourth of their fertilizer the first season and three-fourths the second. And in spite of their having the poorest juices, they had enough more cane to overbalance the C and D plots, which had considerably better juices and which received their fertilizers in two doses, the former all in the second season and the latter, half in the first and half in the second season.

GROVE FARM PLANTATION EXPTS. 2,3,4 & 5, 1922 CROP

EXP. 2 AMOUNT TO APPLY. EXP. 3. TIME OF APPLICATION.

EXP. 4 AMOUNT TO APPLY. EXP 5. FORMS OF NITROGEN.

Field 6. 2nd Ratoons, Long.



SUMMARY OF RESULTS

EXP. 2.

Plots	No. of Plots	Treatment	Yields Per Acre Cane	Q.R.	Sugar
X	18	No Fertilizer	27.66	7.55	3.66
A	10	1000 lbs. Nitrogen Mixture	35.69	7.93	4.50
B	9	2000 lbs. Nitrogen Mixture	35.03	7.87	4.45

EXP. 3.

Plots	No. of Plots	Treatment October 1920.	March 1921.	June 1921.	Yields Per Acre Cane	Q.R.	Sugar
A	15	250# Nit. Mixt.	500# Nit. Mixt.	250# Nit. Mixt.	39.51	8.15	4.85
C	8	—	500# Nit Mixt.	500# Nit Mixt.	35.98	7.87	4.57
D	8	500# Nit. Mixt.	500# Nit. Mixt.	—	34.94	7.54	4.63

EXP. 4.

Plots	No. of Plots	Treatment	Yields Per Acre Cane	Q.R.	Sugar
C	8	1000 lbs. Nitrogen Mixture - March 1921.	37.59	7.77	4.84
E	8	500 lbs. Nitrogen Mixture - March 1921.	37.92	7.44	5.10

EXP. 5.

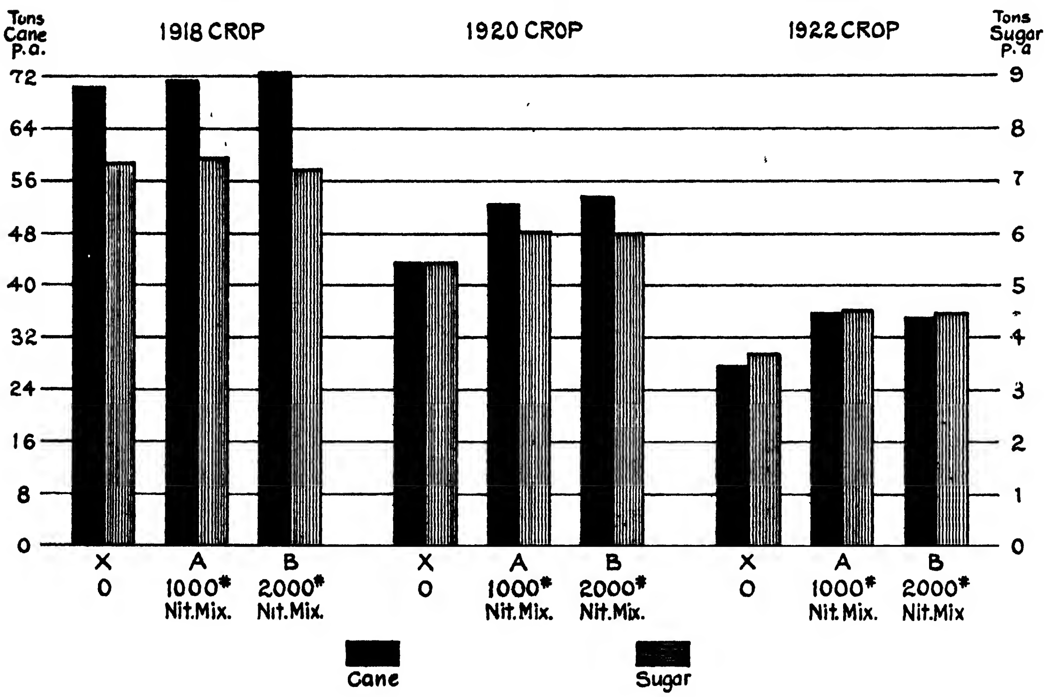
Plots	No. of Plots	Treatment	Yields Per Acre Cane	Q.R.	Sugar
A	14	250# Nit. Mixt. Oct. 1920., 750# Nit Mixt. March	35.10	8.14	4.31
F	8	1000 lbs. Nitrogen Mixture - October 1920.	35.86	8.41	4.26
G	8	1250 lbs. Dried Blood 12% N. October 1920.	35.02	8.96	3.91

The cane of Experiment 4 received all of its nitrogen the second season. In all three crops the cane in the C and E plots was practically the same. But the E plots, receiving only half the amount of nitrogen as the C plots, invariably had better juices and produced more sugar per acre.

In Experiment 5, comparing the forms of nitrogen, dried blood did not give quite as good results for the three crops as a nitrogen mixture. The blood was applied in one dose the first season, while the nitrogen mixture was applied in one dose to the F plots and in four doses to the G plots, (G plots in second ratoon received nitrogen mixture in two doses). With the exception of the first ratoon crop, the nitrogen mixture both in the A and F plots produced better juices than the dried blood.

AMOUNTS OF NITROGEN

GROVE FARM PLANTATION EXP. 2, 1918, 1920 & 1922 CROPS



GROVE FARM PLANTATION CO. EXPERIMENT 2, 1922 CROP.

Fertilizer Experiment—Amount to Apply—Second Ratoons.

0, 150, 300 lbs. nitrogen per acre.

Object:

To determine the most profitable amount of nitrogen to apply to ratoon cane.

Location:

Field 6.

Crop:

D 1135, 2nd ratoons, long.

Layout:

Number of plots: 37.

Size of plots: 1/10 acre each (90.2′x 48.3′).

Plots one watercourse wide and end boundaries marked by small stakes in cane rows. Rows irregular.

Plan:

Fertilization — Pounds N. M. per Acre.

Plot	No. of Plots	October 1920	March 1921	May 1921	Total Pounds Nitrogen
X	18	...	...	...	...
A	10	250	750	250	150
B	9	500	1,500	500	300

Fertilizer used: Nit. mix., 15% N. (6% nit., 6% sul., 3% org.).

All plots received a uniform dose of 500 pounds of reverted phosphate per acre in October, 1920.

Experiment originally planned and laid out by L. D. Larsen.

Experiment revised by R. S. Thurston and J. A. Verret.

Experiment conducted by J. H. Midkiff.

Chemical analyses by A. H. Chase.

Grove Farm Plantation Co. Experiment 3, 1922 Crop.

Fertilizer Experiment — Time of Application.

Object:

To determine the best time to apply a given amount of fertilizer to ratoon cane.

Location:

Field 6.

Crop:

D 1135, 2nd ratoons, long.

Layout:

Number of plots: 31.

Size of plots: 1/10 acre each (90.2′x 48.3′).

Plots one watercourse wide and bounded at ends by small stakes in cane rows. Rows irregular.

Plan:

Fertilization — Pounds N. M. per Acre.

Plot	No. of Plots	October 1920	March 1921	Total Pounds Nitrogen
A	15	250	500	150
C	8	...	500	150
D	8	500	500	150

Fertilizer: 15% N. (6% nit., 6% sul., 3% blood).

Experiment originally planned by L. D. Larsen.

Experiment revised by R. S. Thurston and J. A. Verret.

Experiment conducted by J. H. Midkiff.

Chemical analyses by A. H. Chase.

Grove Farm Plantation Co. Experiment 4, 1922 Crop.

Fertilizer Experiment — Amount to Apply — Second Season.

Object:

To determine the most profitable amount of fertilizer to apply to ratoon cane during the second season.

Location:

Field 6.

Crop:

D 1135, 2nd ratoons, long.

Layout:

Number of plots: 16.

Size of plots: 1/10 acre each (90.2'x 48.3').

Plots one watercourse wide and bounded at ends by small stakes in cane rows. Rows irregular.

Plan:

Fertilization — Pounds N. M. per Acre.

Plot	No. of Plots	Aug. 1920	Nov. 1920	March 1921	Total Nitrogen
C	8	....	....	1,000	150
E	8	....	....	500	75

Fertilizer: 15% N. (6% nit., 6% sul., 3% org.).
Experiment originally planned and laid out by L. D. Larsen.
Experiment revised by R. S. Thurston and J. A. Verret.
Experiment conducted by J. H. Midkiff.
Fertilizer analyses by A. H. Chase.

Grove Farm Plantation Co. Experiment 5, 1922 Crop.

Fertilizer Experiment — Forms of Nitrogen.

Object:

To compare the relative value of equal amounts of nitrogen from the following sources: organic (dried blood) and a 15% nitrogen mixture composed of 6% from nitrate, 6% from sulfate and 3 % from blood.

Location:

Field 6.

Crop:

D 1135, 2nd ratoons, long.

Layout:

Number of plots: 30.

Size of plots: 1/10 acre each (90.2'x 48.3').

Plots one watercourse wide and bounded at ends by small stakes in cane rows. Rows irregular.

Plan:

Fertilization — Pounds per Acre.

Plot	No. of Plots	Fert.	October 1920	March 1921	Total Nitrogen
A	14	N. M.	250	750	150
F	8	N. M.	1,000	...	150
G	8	Blood	1,250	...	150

Fertilizer: Nit. mix., 15% N. (6% nit., 6% sul., 3% blood); blood 12% N.
Experiment originally planned and laid out by L. D. Larsen.
Experiment revised by R. S. Thurston and J. A. Verret.
Experiment conducted by J. H. Midkiff.
Fertilizer analyses by A. H. Chase.

Juice Extraction by Centrifugal Force.

By H. D. Beveridge.

During the 1921 crop at Onomea several experiments were carried on with shredded cane to determine the amount of juice that could be separated by centrifugal force, in an ordinary centrifugal.

Cane was passed directly into the shredder, in order to get the shredded product from cane that had not passed through the crusher. This was analyzed for percent sugar, moisture and fiber. About 150 pounds was weighed, and spun for twenty minutes in an ordinary 40″ Mackintosh centrifugal at 1100 R. P. M. The free juices thrown off were weighed to determine the percent extraction, and analyzed for Brix, sugar and purity.

The residue was washed in the centrifugal with 50 percent of its original weight of water, and spun for fifteen minutes after the water was stopped. The resultant bagasse was removed, weighed, and analyzed for percent sugar, moisture and fiber.

Experiment No. 1 was not washed, as we found, after spinning some time, that the centrifugal was not properly cleaned out, and it was necessary to weigh the bagasse instead of the juice to determine the extraction. In the other tests the juice extraction was determined by weighing free juices thrown off as above described.

The results of these experiments may be of interest and are tabulated next page:

Sample	1*	2	3	4
Shredded Cane—				
Weight (lbs.)	150.0	153.0	149.0	151.5
Polarization	11.93	10.86	11.69	10.00
Moisture	71.0	74.8	72.4	72.0
Fiber	13.35	12.70	14.25	12.75
Undiluted Juice—				
Brix	20.97	15.82	16.15	18.50
Polarization	16.09	12.93	13.72	15.46
Purity	76.7	81.8	84.9	83.6
Pounds bagasse before washing	72.0	86.0	85.0	82.0
Pounds undiluted juice extracted	78.0	67.0	64.0	66.5
Wash water added % cane	.....	50	50	½" hose 5 min.
Time of spinning after washing (minutes)	.....	15	15	15
Final Bagasse—				
Polarization	9.42	4.44	7.35	5.47
Moisture	58.4	67.0	65.0	66.0
Fiber	29.4	25.5	26.25	27.0
Weight (lbs.)	.....	78.5	77.0	78.0
Extraction Data—				
Undiluted juice % cane	52.0	43.8	43.0	43.9
Total extracted juice % cane	52.0	48.7	48.3	48.5
Juice extracted % juice in cane	60.0	55.8	56.3	55.6
Pol. extracted % pol. in cane	62.1	79.0	67.5	71.8
Speed of Centrifugal (R. P. M.)	1110	1080	1095	1104

* This sample was not washed. The analysis is that of the bagasse remaining after the undiluted juice was thrown off.

It is shown by actual tests, that it is possible to extract nearly eighty percent of the total sugar in shredded cane by means of an ordinary centrifugal at 1100 R. P. M., exerting about 700 pounds pressure per square inch. What extraction could be obtained with an apparatus capable of double or treble that speed?

Papaikou, October 20, 1921.

Why Do Rats Eat Cane?

By Edw. L. Caum.

It is undeniable that rats are an exceedingly undesirable part of the population of a cane field, but it is an open question as to whether they are wholly responsible for all the damage that is laid at their door. It is not known just what part the cane plays in the rat's domestic economy — whether it is an important part of his diet or whether it is not. For the purpose of throwing a little light on this question, the experiment detailed below was carried out.

On December 28, 1921, the Experiment Station possessed ten white rats (the albino form of the common brown rat), consisting of four males and six females. Their exact age was not known, but was somewhere between three and four months. On that date four of these animals, two males and two females, were placed in another cage and fed on sugar cane and water exclusively. The remaining six rats were kept as checks, being fed their regular diet, which consisted mainly of bread, with various extras in the way of canna roots, pualele *(Sonchus)*, lettuce and the like.

On February 18, 1922, the fifty-third day of this selective feeding, the experiment was discontinued, and the experimental animals carefully compared with the checks. The four rats which had been fed on cane alone were small, sluggish, unsteady on their feet, and scarcely able to open their eyes wide. Their fur was yellowish, and they showed all the signs of being in an extremely unhealthy condition. They had not bred, or if they had the young had been eaten immediately after birth. There was never any sign of young noted in the cage. The check animals, on the other hand, were much larger and were very active and alert. Their fur was the pure white that it should be, and each of the females had produced a good-sized litter of young. The difference in the appearance of the two lots was striking, but an even more striking difference was noted when the animals were weighed. The four rats from the experimental cage weighed, respectively, 66, 64, 51 and 40 grams, an average of 55.25 grams each. Four of the check animals, and not the four largest, weighed 171, 154, 150 and 135 grams, an average of 152.50 grams each, or nearly three times the weight of the cane-fed rats.

During the two weeks between February 18 and March 4, the four experimental animals were given the same diet as those in the check cage. At the end of the first week they weighed 82, 81, 62 and 54 grams, averaging 69.75 grams each, having gained a trifle over 26% in one week of feeding on a mixed diet. At the end of the second week they weighed 95, 90, 71 and 58 grams, an average of 78.50 grams each. This represents a further gain of 12.55% over their weight of the week before, or a total gain of 42.81% in the two weeks of feeding on a more balanced ration. This seems to indicate that sugar cane is certainly not a very important part of the rats' menu.

From the condition of the experimental animals after fifty-two days on an exclusive sugar cane diet, and from the way their condition improved in two

weeks on a mixed diet, it looks very much like a case of partial starvation. The animals themselves gave the clue to the critical substance that was lacking in the manner in which they attacked the cane given them. They would first gnaw out the eyes, and then scrape the root-band clean, before eating out the pith. In other words, they first ate the embryonic tissue, the protein-bearing part of the cane stalk. This is a decided contrast to the habits of the field rats, which gnaw out the pith from the internodes, leaving the nodes untouched. The accompanying illustration clearly shows this contrast.

This experiment seems to indicate that rat damage to sugar cane is after all incidental, and that the animals can easily exist in a cane field without making use of the cane as an article of diet at all. The various insects and weeds present in the fields would furnish them with a completely balanced ration.

However, it is certain that rats do destroy a large amount of cane, and when we seek the reason, borers should be given the first consideration. The larvae of these insects are a very acceptable article of food for rats, and it is entirely possible that the rats learned to eat cane in the course of their excavating the stalks in search of these larvae. Various theories have been advanced concerning the relation between rats and borers. One is that the rats eat cane as an ordinary article of food — make it an integral part of their diet, and that the cane so damaged attracts the borers, because the gnawed portions greatly facilitate egg-laying. In other words, the borers follow the rats. Another theory is just the reverse of this. According to this, the borers were there first, and the rats attack the cane, hollowing out the joints in their search for the borer larvae. It is a well-known fact that insects are an important part of a rat's diet. Rat-eaten cane in the field, if not too badly fermented and covered with fungi, will frequently show traces of borer infestation. In the stick shown at the left of the illustration there were very evident traces of borers in two joints. The others were too badly gnawed to make a definite determination of this point possible.

A slight bit of additional evidence in favor of the second hypothesis may be seen in the following incident. In the course of the feeding experiment just described, a piece of cane containing a borer larva was given to the check rats. Although these animals had never seen a borer larva before, they showed no hesitation at all in consuming this one, and then they completely hollowed out the joints through which the borer had worked before making any attempt to eat into the sound joints above. When they had finished with the stick, it looked very much like the rat-eaten cane found in the fields. This may indicate why rat-eaten cane does not more commonly show evidences of previous borer infestation.

The two sticks on the left are rat-eaten cane from the fields. Note that the internodes are well hollowed out, but the eyes and root-bands are intact. Note the borer channel at the top of the stick on the left. Borer larvae had been through the middle internode of this stick as well.

Those to the right are specimens of the cane eaten by the experimental rats. Note how the eyes are gnawed out and the root-bands scraped clean.

Plows vs. Hoes.

By J. A. Verret.

Onomea Experiment No. 12, 1922 Crop.

This experiment was planned by the plantation and conducted by it, except that the Station fertilized the plots and harvested the experiment. The labor distribution in the different operations was kept by the plantation.

The experiment consisted of twelve plots, each 1/10 acre. There were six repetitions of each treatment. The cane was Yellow Caledonia, first ratoons, long. All plots were shaved with a stubble shaver, after which the experimental treatments were begun. All plots were fertilized as follows:

September 11, 1920	February 1, 1921	June 1, 1921
500 lbs. B 7 * 200 lbs. Pt. Nit.	500 lbs. B 7 *	400 lbs. Nit. Soda

* B 7 = 11% N., 6% P_2O_5, 6% K_2O.

The labor distribution in hours per acre is as follows:

	Plantation Practice		Hoes Only
	Men	Animals	Men
Off-barring	6.95	6.95	......
Cultivating	15.96	15.96	......
Fertilizing	8.22	......	8.50
Covering Fertilizer	13.33	3.33	22.20
Hoeing	102.39	......	234.10
Harrowing	5.15	5.15	......
Hilling plows	8.33	8.33	......
Hilling hoes	4.80	......	......
Total	165.13	39.72	264.80

The yields obtained are given in the following tabulation:

Treatment	Yield per Acre		
	Cane	Q. R.	Sugar
Plantation Practice	50.1	10.18	4.92
Hoes Only	54.0	9.73	5.55

From the above we see that the plows were actually detrimental to yields, and that hoes only were more expensive and used up much more man labor, which is something to be avoided at the present time.

The logical method of procedure would therefore seem to be to cover fertilizer and control weeds as much as possible with surface implements to avoid disturbance to the root systems of the growing cane.

Evidently the benefits, if any, derived from the use of plows is not great enough to make up for the check caused by root destruction. This is indicated to some extent by notes taken in this field on December 24, 1920, by W. L. S. Williams.

Mr. Williams states: "In the cultivation experiment (Exp. No. 12, 1922 crop) the X plots which have received off-barring and regular plantation cultivation have far better color, but the A plots, where no animal work has been done, are noticeably higher in growth."

Details of Experiment.

Object:

To determine the value of cultivation practices comparing:

1. Plantation practice, including off-barring, middle-breaking and hilling (X).
2. No animal cultivation — hoeing only (A).

Location:

Onomea Sugar Co., Field 82.

Crop:

Yellow Caledonia, 1st ratoons.

Layout:

Number of plots — 26.

Size of plots — 1/10 acre, consisting of 6 lines, each line 5.93 ft. wide and 122.5 ft. long. Lines 1 and 6 are guard lines, to be discarded on harvesting, and lines 2, 3, 4 and 5 of each plot harvested as experiment.

Plan:

Fertilization:

Uniform to all plots, and to be applied by Station representative as follows:

Sept. 20, 1920 — 500 lbs. B-7 per acre and 200 lbs. Pot. Nit.
Dec. 1, 1920 — 500 lbs. B-7 per acre.
April 1, 1921 - 400 lbs. N. S. per acre.
B-7 = 11% N.; 6% P_2O_5, 6% K_2O.
N. S. = 15.5% N.

Cultivation:

Time to be kept separately for A and X plots by plantation team-luna. Station representative to be present whenever possible.

Cultivation Practices.

HALAWA PLANTATION EXPERIMENT NO. 1, 1922 CROP.

Various cultivation practices were compared in this test. In one series of plots the so-called plantation practice was followed. This included offbarring and hilling. In a second series, cultivators were used for weeding and for covering the fertilizer. No plows were used. In the third series of plots no animals were used, the weeding and covering of the fertilizer being done by hoes.

The cane was Yellow Caledonia, first ratoons, long, and was harvested in February 1922, at the age of 23 months. The previous crop was harvested in March 1920.

On August 12 to 14, all the plots were hoed, then on the 17th, the X plots were offbarred and on August 20, all plots received 500 pounds per acre of complete fertilizer. The fertilizer in the X and A plots was covered with a cultivator, while in the B plots it was done with hoes. In covering the fertilizer, the cultivator was run twice on each row. All plots were hoed the second time on October 6 and on the 7th all plots were fertilized. The fertilizer on the X plots was covered with plows in the hilling up, that on the A plots was covered with cultivators as previously, and that in B with hoes.

The labor distribution in hours per acre for these different operations is given as follows:

	X PLOTS Plantation Practice		A PLOTS Cultivators and Hoes		B PLOTS Hoes Only	
	Men	Animals	Men	Animals	Men	Animals
Hoeing	16.2	....	16.4	....	16.5	....
Applying fertilizer	4.0	....	4.0	....	4.0	....
Covering fertilizer and hilling	8.8	8.8	6.3	6.3	17.3	....
Offbarring	7.7	7.7	....	....	....	....
Total	36.7	16.5	27.7	6.3	37.8	0.0

The yields per acre obtained are given in the following table:

Plots	Treatment	Yield per Acre Cane	Q. R.	Sugar
X	Offbarring, plowing, etc.	29.8	8.07	3.70
A	Cultivators and hoes, no plows	29.3	8.01	3.65
B	Hoes only	29.0	8.09	3.59

The yields were substantially the same for all treatments. By omitting offbarring and hilling and controlling weeds as much as possible with cultivators, a distinct saving in labor was shown, and is to be preferred to either of the other methods.

In order to see if plowing becomes necessary in time we plan to continue this experiment in the same way until the field is again plowed for planting.

J. A. V.

Preliminary Investigations in Seed Germination.

By Wm. W. G. Moir.

Single eye cuttings have been used in our study of the heritable characters of the progenies in the bud selection project. They have been started in pots and later set out in the field a uniform distance apart. Only plants of a uniform size and vigor were planted out so as to insure an even stand in each progeny. To get a better understanding of the behavior of these cuttings, and seed in general as to treatments and methods of handling, so as to insure a quicker and more uniform germination, we have carried out a few experiments on germination of these cuttings.

Nursery flats holding nine single eye cuttings of H 109 cane were used throughout the experiments and the sand-soil mixture of one part sand to four parts soil was used in all cases where the treatment did not call for some other soil medium. In all treatments sufficient repetitions and checks were made, and seed from different stalks and stools was well mixed to insure more uniform and trustworthy results. Observations and recording of germinations were made from day to day for a period of six weeks, at which time the experiments were abandoned. The results obtained are applicable only to material handled under the above conditions, but many suggestions may be obtained for plantation practice. We intend carrying out a few of these in further field tests at Waipio later on this year.

An outline of the object and results of each of the experiments follows:

Experiment 1.

Object:

Single eye cuttings vs. three joint one eye cuttings (the two end eyes gouged out), having the eye:

(1) On the top of the cutting when placed in the flat.
(2) On the side of the cutting when placed in the flat.
(3) On the bottom of the cutting when placed in the flat.

Results:

1. Cuttings placed so that the eyes were on the top germinated one week sooner than those on the side, and two weeks sooner than those on the bottom and maintained this lead throughout the six-week period.
2. Single eye cuttings germinated sooner than the three joint one eye cuttings, but the three joint cuttings grew faster after germination and soon surpassed the one joint cuttings in growth.
3. Germinations were much better from eyes turned up or on the side than from those turned down.
4. Shoots arising from the three joint one eye cuttings were much more vigorous and larger than those from the single eye cuttings.

Experiment 2.

Object:

1. Single eye cuttings cut close to the node vs. those cut as long as possible.
2. The above tried out under the following soil or planting media:
    1. Ordinary soil.
    2. Sterilized soil.
    3. Ordinary beach sand (coral).
    4. Sterilized beach sand (coral).
    5. Ordinary charcoal.
    6. Sterilized charcoal.
    7. Sand-soil mixture (1 to 4).
    8. Charcoal-soil mixture (1 to 4).

Results:

1. Long cuttings gave slightly better germination and more vigorous shoots than the short cuttings.
2. Soil media in order of germination rates are as follows: Charcoal, sand-soil, charcoal-soil, soil, and beach sand. In order of growth rate after germination: Sand-soil, soil, charcoal-soil, beach sand, charcoal.
3. No beneficial results were obtained from sterilizing the media.
4. The increased rate of germination in the charcoal flats was probably due to the greater absorption of heat by the black color, and the poor rate of growth afterwards to the lack of food.
5. The sand-soil mixture gave the best results and pure beach sand the poorest.

Experiment 3.

Object:

1. Single eye cuttings from the upper one-third of the stalk (top) vs. those from the middle one-third (body) vs. those from the lower one-third of the stalk (butt).
2. The above tried out under the following fungicidal treatments:
    1. Cuttings exposed to sunshine for one hour.
    2. Cut ends smeared with copper sulphate-starch paste.
    3. Cuttings dipped in bichloride of mercury for five minutes.
    4. Cuttings dipped in Bordeaux mixture for five minutes.
    5. Cut ends dusted with flowers of sulphur.

        Bichloride of mercury — 1 to 1000.
        Bordeaux mixture — 5–5–50.

Results:

1. Injurious effects were obtained in the treatments with copper-starch paste, bichloride of mercury, and Bordeaux mixture:
    a. No germination in the copper-starch paste till the sixth week, when one eye germinated.
    b. Only a 25 percent germination in the bichloride treatment.
    c. Only 75 percent germination in the Bordeaux mixture.
2. Exposure to the sun for one hour had no bad effects nor any beneficial effects to the top seed, but had a retarding effect on the body and butt seed.
3. Flowers of sulphur was neither beneficial nor detrimental.
4. Top seed germinated quicker and gave a higher percentage of germination than body and butt seed.
5. Body and butt eyes were about equal in all treatments.

Experiment 4.

Object:

Top, body and butt seed unsoaked vs. top, body and butt seed soaked:

1. Ten minutes at 60° C.
2. Twenty-four hours in ordinary water—
   a. Left in long pieces.
   b. Cut into single eye cuttings.
3. Forty-eight hours in ordinary water—
   a. Left in long pieces.
   b. Cut into single eye cuttings.

Seed soaked in long pieces was cut into single eye cuttings before planting.

Results:

1. Top eyes germinated quicker and gave a higher percentage of germination in all treatments except the ten minutes at 60° C. and the forty-eight hours (single eyes) soaking.
2. All eyes treated for ten minutes at 60° C. were damaged so badly that only three were able to germinate about the end of the sixth week.
3. Soaking for twenty-four hours had no beneficial effects over planting without soaking, and with long seed there was a slight retarding of germination.
4. Soaking for forty-eight hours with the seed cut into single eye pieces gave the maximum rate of germination for top, body and butt seed. This jump at the start over the rest of the treatments was maintained throughout the whole six weeks.
5. The seed left long and soaked did not compare with the single eye cuttings soaked; the period of soaking was not long enough, so no benefit was obtained and a slight retarding of germination resulted from this extra handling.
6. Body and butt seed soaked came up quicker and evener than body and butt seed unsoaked.

Experiment 5.

Object:

Top, body and butt seed under the following treatments:

1. Single eyes cut and planted the same day that the material for treatment 2 was topped.
2. Single eyes from stalks, topped ten days before planting.
3. Single eyes from untopped stalks planted the day that treatment 2 was planted.

In topping the stalks for treatment 2 the cane top was removed for the top seed, the upper one third of stalk for the body seed, and the upper two-thirds for the butt seed.

Results:

1. Germinations were recorded three days from planting in the topped seed.
2. One week after planting, the topped seed — top, body, and butt — had surpassed the seed planted seventeen days before. At the end of the six-week period the percentage of germination in the ordinary seed, cut and planted at the same time as topped seed, was only about two-thirds that of the topped, but the rate of growth had surpassed that of the topped seed.
3. Body and butt seed in the topped treatment gave a very high germination percentage and rate of growth. This was the best stand of body and butt seed throughout the whole five experiments.

General Conclusions.

1. Top seed is to be recommended in preference to body and butt seed, even in one year old cane, as was used in these tests.

2. Placing eyes on top, when single eye cuttings are used, is more beneficial than placing them on the side or bottom.

3. Soaking of seed, especially hard body and butt seed, for from forty-eight to seventy-two hours, changing the water daily, is strongly recommended. Soaking top seed is also beneficial, but is not necessary where the seed would have to be transported long distances to soak. Some form of tank car that could be hauled around to the different fields would overcome this transportation trouble.

4. Topping cane for a period of ten days prior to cutting seed is recommended only where there is a shortage of good seed. Rapid germination is obtained, but more careful handling and care after planting is necessary. The seed will germinate quickly, but the root growth is not fast enough to keep pace with the shoot and often the shoot dies or is set back. Extra irrigation will partially overcome this.

5. Hard body and butt seed should not be exposed to the sun, even when bagged, any longer than necessary. Cover the seed with trash.

6. Three joint one eye cuttings are recommended for single eye stooling investigation, as more vigorous shoots are obtained in a shorter time.

7. Soil-sand mixture of four to one is the best planting medium.

8. Flowers of sulphur is the only fungicidal treatment tried that can be recommended.

9. If single eye cuttings are to be used, cut them as long as possible.

10. Only vitally strong stalks should be used for seed. Very small stalks give poor results, and extra large suckers which are immature and soft may also lack vitality.

Most plantation men fail to realize the fact that top seed should be used in preference to body and butt seed; many of them are beginning to realize the importance of the size of the stalk used for seed; but very few agree on the question of soaking seed. There are plantations where no seed is planted that has not soaked for from 48 to 72 hours, and there are many that do not soak their seed at all, while in between we have them soaking seed from a few hours up to a day. Much more experimenting on this subject should be carried out. The harm that is done by the extra handling of soaking in the short periods more than balances the benefits derived from the soaking. To really get the benefits from soaking the seed must be completely penetrated, and this cannot be brought about in a few hours' soaking. From the results obtained in the tests above I am sure that seed should be either soaked from 48 to 72 hours or not soaked at all.

Experiments at Maui Agricultural Company.

By J. A. Verret.

GENERAL.

These experiments were on the Maui Agricultural Company plantation, in field 83, Keahua section, at an elevation of about 500 feet. They were 1921 crop experiments, but on account of great delay in harvesting, due to abnormal labor conditions last year, it was necessary to carry them over to the 1922 crop. They were, therefore, harvested in January 1922.

During its growing period the cane in these experiments suffered a great deal from lack of water, more particularly during 1921, when the field received but two regular irrigations. The rainfall for the year in that section amounted to 24.76 inches, 18.47 inches of which fell in January, November and December. The cane dried up badly.

Therefore the results obtained from these experiments are to be considered as referring to conditions of extreme water and labor shortage, and are not necessarily the same as would be expected under normal conditions. The cane was plant, 22 months old at harvest.

The results obtained from this series of experiments are briefly summarized as follows:

First. Under conditions of labor and water shortage, and delay in harvesting from a sugar production point of view, H 109, Rose Bamboo, and D 1135 are of about equal value as plant cane. The selection of a variety for this section should therefore be based, to some extent, on the field and milling qualities of the cane. We should be inclined to favor H 109, as it is more likely to respond to better conditions. On the other hand, were conditions to remain bad, D 1135 would probably give better ratoons.

Second. Neither phosphoric acid nor potash produced enough increase in yield to pay for its cost.

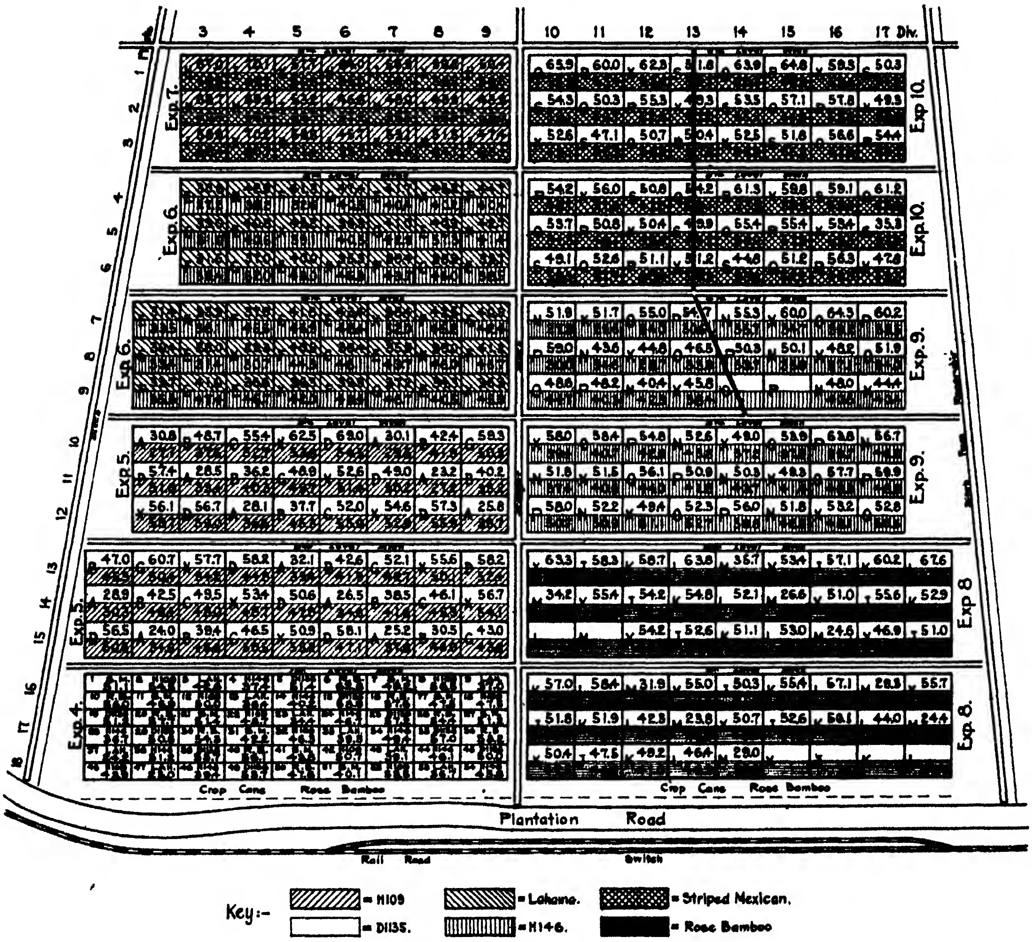
Third. The economic limit in nitrogen was 175 pounds of this element per acre, equal to about 1,100 pounds of nitrate of soda.

Fourth. Applying a given amount of fertilizer in two doses gave better results than when applying it in three or four.

Fifth. Equal amounts of nitrogen from nitrate of soda, ammonium sulphate, a mixture of equal amounts of nitrate and sulphate, and dried blood gave about equal yields of sugar. The blood was the most expensive.

Exp. 4 Variety Test.
Exp 5. Amount To Apply.
Exp 6. Proportion Each Season.
Exp 7. Phosphoric Acid Test.
Exp. 8. Plant Food Requirements.
Exp. 9. Time & Number of Applications.
Exp. 10. Forms of Nitrogen

Maui Agricultural Co Expts. 4, 5, 6, 7, 8, 9 & 10, 1923 crop



Experiment No. 4 — Varieties of Cane.

In experiment 4, Lahaina, H 146, H 109, Striped Mexican, Rose Bamboo, and D 1135 were compared with the following results:

Variety	Yield per Acre		
	Cane	Q. R.	Sugar
Rose Bamboo	55.5	8.83	6.29
H 109	50.2	8.02	6.26
D 1135	54.0	8.64	6.25
Striped Mexican	47.0	8.43	5.58
H 146	41.4	9.53	4.35
Lahaina	35.0	9.26	3.78

Of the above varieties Rose Bamboo germinated the best, and had a faster start, with D 1135 next best, followed by H 109. H 146 was very slow coming up. Rose Bamboo needed no replanting; in all the others some replanting was necessary.

Rose Bamboo, H 109 and D 1135 were of equal value as sugar producers under the conditions which pertained. Both Lahaina and H 146 gave poor results, due mainly to Root-rot. It should be remembered that H 146 is susceptible to Lahaina disease and should never be planted in fields where this disease is known to be present.

The poor juices from the H 146 and the Lahaina were due, in the main. to diseased and dead cane.

This experiment is being continued as short ratoons.

All the varieties have ratooned well except Lahaina and H 146, which will need replanting.

Details of Experiment.

Object:

To compare the following varieties for conditions existing at the southern end of the plantation: Lahaina, Striped Mexican, D 1135, H 109, H 146 and Rose Bamboo.

Location:

Keahua Section, field 83.

Crop:

Six varieties as plant cane. Planted September 1919; harvested January 1922.

Layout:

Number of plots: 54.

Size of plots: 1/20 acre (31.5'x 69'), composed of 7 straight lines, two watercourses long, or 14 single lines, 4.5'x 34.5'.

Plan:

Plots	No. of Plots	November 1919			Feb. 1920	April. 1920	Total Pounds per Acre		
		N.	P_2O_5	K_2O	N.	N.	N.	P_2O_5	K_2O
Lahaina	9	58.3	100	60	58.3	58.3	175	100	60
Striped Mexican.	9	58.3	100	60	58.3	58.3	175	100	60
D 1135	9	58.3	100	60	58.3	58.3	175	100	60
H 109	9	58.3	100	60	58.3	58.3	175	100	60
H 146	9	58.3	100	60	58.3	58.3	175	100	60
Rose Bamboo ...	9	58.3	100	60	58.3	58.3	175	100	60

N. from 17½% nitrogen mixture - half nitrate of soda, half sulf. amm.
P_2O_5 from acid phosphate, 16% P_2O_5.
K_2O from sulfate of potash = 48% K_2O.

EXPERIMENT NO. 5—HOW MUCH NITROGEN TO USE.

In this test the amounts of nitrogen used varied from nothing to 225 pounds per acre. All plots received phosphoric acid and potash in equal amounts, that is, 625 pounds of acid phosphate and 125 pounds of sulphate of potash per acre.

The amounts of nitrogen used and the results obtained are shown as follows:

Variety	Nitrogen—Pounds per Acre	Tons per Acre		
		Cane	Q. R.	Sugar
H 109	No nitrogen	33.2	8.39	3.95
D 1135	" "	27.6	9.39	2.94
H 109	75 pounds nitrogen ...	44.0	8.76	5.03
D 1135	75 " " ...	40.5	9.32	4.35
H 109	125 " " ...	48.8	8.69	5.62
D 1135	125 " " ...	51.3	9.40	5.46
H 109	175 " " ...	53.2	8.42	6.32
D 1135	175 " " ...	55.6	9.00	6.17
H 109	225 " " ...	52.3	8.81	5.94
D 1135	225 " " ...	57.1	9.24	6.18

The nitrogen produced profitable gains up to a limit of 175 pounds per acre, equal to the use of 1,100 pounds of nitrate of soda. Further additions of nitrogen above this amount did not pay.

It is well to remember that this field suffered severely from lack of water during the summer of 1920. With normal water it is possible that larger amounts of fertilizer could have been used to advantage.

But it is apropos to remark here that heavy fertilization should be done carefully. Fields which are likely to suffer from lack of water cannot be expected to show big profits from heavy fertilization. It is also extremely important not to apply big doses of nitrogen late during the second season, as in that case the juices are likely to be poor and although the cane yields may be high, the sugar "in-the-bag" may prove to be disappointing.

At Waipio, where we now use 300 pounds of nitrogen per acre, we make it an invariable rule to have all fertilizing done at least twelve months before the field is to be harvested. By following this routine we have found that by harvest time the stimulating action of the nitrogen has stopped and that we are able properly to mature the cane. We are harvesting at present cane running above 100 tons to the acre with quality ratio about eight. Had this cane been fertilized late last year, instead of February, the quality ratio, we have reason to know, would be nine or ten.

As a result of our work at Waipio and of our field experiments on the other islands, we are convinced that late fertilization is more detrimental to juices than is heavy fertilization when done at the proper time.

Details of Experiment.

Object:

To determine the most profitable amount of nitrogen for the Keahua lands.

Location:

Field 83, Keahua Section.

Crop:

D 1135 and H 109 plant cane, planted September 1919; harvested January 1922.

Layout:

Number of plots = 51.

Size of plots: 1/10 acre (63'x 69'), composed of 14 lines, two watercourses long, or 28 single lines, 4.5'x 34.5'. Each plot contains D 1135 and H 109, and each variety occupies 7 lines two watercourses long.

Plan:

Fertilization in Pounds per Acre per Application.

Plot	No. of Plots	November 1919			Feb. 1920	April 1920	Total Pounds per Acre		
		N.	P_2O_5	K_2O	N.	N.	N.	P_2O_5	K_2O
A	11	....	100	60	....	....	...	100	60
B	11	25	100	60	25	25	25	100	60
C	10	41.6	100	60	41.6	41.6	125	100	60
X	9	58.3	100	60	58.3	58.3	175	100	60
D	10	75	100	60	75	75	225	100	60

N. = Nitrogen from 17½% nitrogen mixture, half nit. soda, half sulf. amm.
P_2O_5 = Phosphoric acid from acid phosphate = 16% N.
K_2O = Potash from sulfate of potash = 48% K_2O.

EXPERIMENT NO. 6—PROPORTION OF NITROGEN TO APPLY EACH SEASON.

In this experiment we applied 175 pounds of nitrogen per acre to all plots, but it was applied at different times to the different plots. All plots also received 625 pounds of acid phosphate and 125 pounds of sulphate of potash per acre.

Both Lahaina and D 1135 in this area suffered to some extent from Root-rot. Cane suffering from this disease responds but little to fertilization. For this reason the results obtained from this test are not to be accepted as in any way conclusive. They are reported here to complete the record.

The results of the harvest are as follows:

Variety	Treatment	Tons per Acre		
		Cane	Q. R.	Sugar
H 146	All nitrogen applied 2nd season, Feb. and April.	40.8	9.73	4.20
Lahaina ...	All nitrogen applied 2nd season, Feb. and April.	36.4	9.81	3.71
H 146	All nitrogen applied 1st season, in November ...	43.2	9.56	4.52
Lahaina ...	All nitrogen applied 1st season, in November ...	38.9	9.97	3.90
H 146	One-third in Nov., two-thirds in Feb. and April.	41.7	9.92	4.21
Lahaina ...	One-third in Nov., two-thirds in Feb. and April.	38.2	10.13	3.77
H 146	Two-thirds in Nov., one-third in Feb. and April.	42.0	9.61	4.37
Lahaina ...	Two-thirds in Nov., one-third in Feb. and April.	39.0	10.27	3.80

The differences here are not very great, but indicate a preference for the early applications of fertilizer.

Details of Experiment.

Object:

To determine what proportion of the fertilizer to apply each season.

Location:

Field 83, Keahua Section.

Crop:

H 146 and Lahaina plant cane, planted September 1919; harvested January 1922.

Layout:

Number of plots: 45.

Size of plots: 1/10 acre (composed of 14 straight lines) two watercourses long, or 28 single 4.5'x 34.5'. Each plot contains two varieties and each variety occupies 7 lines two watercourses long.

Plan:

Proportion of Fertilizer per Season and Application.

Plots	No. of Plots	1st Season	Second Season		Total Pounds		
		Nov. '19	Feb. '20	Apr. '20			
		N.	N.	N.	N.	P_2O_5	K_2O
E.......	12	...	1/2	1/2	175	100	60
X.......	11	1/3	1/3	1/3	175	100	60
F.......	11	2/3	1/6	1/6	175	100	60
G.......	11	All	...	...	175	100	60

All plots are to receive in the first fertilization 100 pounds P_2O_5 from acid phosphate and 60 pounds K_2O from sulfate of potash.

Nitrogen to be applied as 17½% N. mixture, half nitrate of soda, half sulfate of ammonia.

EXPERIMENT NO. 7—PHOSPHORIC ACID.

In this area we compared varying amounts of phosphoric acid, ranging from 50 to 150 pounds of P_2O_5 per acre. All plots received nitrogen at the rate of 175 pounds per acre and 60 pounds of potash.

The results obtained are given in the following table:

SUMMARY OF YIELDS.

Variety	Treatment—Pounds per Acre	Tons per Acre		
		Cane	Q. R.	Sugar
H 109...........	312 pounds acid phosphate ..	58.4	8.45	6.91
Striped Mexican..	312 " " " ..	62.8	8.71	7.21
H 109...........	625 " " " ..	54.9	8.80	6.24
Striped Mexican..	625 " " " ..	61.5	9.23	6.66
H 109...........	937 " " " ..	54.1	8.89	6.09
Striped Mexican..	937 " " " ..	61.1	9.04	6.76

Increasing the phosphoric acid above 50 pounds per acre was of no value; in fact, the yields were lower. These results are confirmed by those from experiment 8, where there was no appreciable response from phosphoric acid.

An analysis of the soil in this field showed:

Citrate soluble $P_2O_5 = .0095\%$

This soil is, therefore, well supplied with phosphoric acid and will be for some years to come.

Details of Experiment.

Object:

To determine the amount of phosphoric acid to apply under these conditions.

Location:

Field 83, Keahua Section.

Crop:

H 109 and Striped Mexican plant cane, planted September 1919; harvested January 1922.

Layout:

Number of plots 21.

Size of plots: 1/10 acre (63'x 69'), composed of 14 straight lines two watercourses long, or 28 single lines 4.5'x 34.5'. Each plot contains two varieties and each variety occupies 7 lines two watercourses long.

Plan:

Plots	No. of Plots	November 1919			Feb. 1920	April 1920	Total Pounds per Acre		
		N.	P_2O_5	K_2O	N.	N.	N.	P_2O_5	K_2O
H	7	58.3	50	60	58.3	58.3	175	50	60
X	7	58.3	100	60	58.3	58.3	175	100	60
I	7	58.3	150	60	58.3	58.3	175	150	60

N. from 17½% nitrogen mixture, half Nit. Soda, half Sulf. Amm.

P_2O_5 acid phosphate $= 16\%$ P_2O_5.

K_2O sulfate of potash $= 48\%$ K_2O.

EXPERIMENT NO. 8—NITROGEN, PHOSPHORIC ACID AND POTASH.

We here tried different combinations of the three main plant foods, nitrogen, phosphoric acid and potash. The nitrogen was kept constant at 175 pounds per acre, except in one series of plots where no nitrogen was used. The results from the different treatments are summarized on the next page:

Summary of Treatments and Yields.

Variety *	Treatment	Tons per Acre		
		Cane	Q. R.	Sugar
Rose Bamboo	Nitrogen only	48.3	8.67	5.57
D 1135	Nitrogen only	53.9	9.29	5.80
Rose Bamboo	Nitrogen and phosphoric acid	49.7	8.72	5.70
D 1135	Nitrogen and phosphoric acid	53.1	8.94	5.94
Rose Bamboo	Nitrogen and potash	48.0	8.92	5.38
D 1135	Nitrogen and potash	54.1	9.06	5.97
Rose Bamboo	Nitrogen, phosphoric acid and potash.	47.7	8.80	5.42
D 1135	Nitrogen, phosphoric acid and potash.	53.6	8.63	6.21
Rose Bamboo	Phosphoric acid and potash	32.1	9.29	3.45
D 1135	Phosphoric acid and potash	29.4	9.32	3.15

The response to 175 pounds of nitrogen amounted to over two tons of sugar per acre. Neither phosphoric acid nor potash, alone or together, produced any profitable gains.

A soil analysis from this field showed the soil to be well supplied with both of these plant foods. The amounts found were as follows:

Citrate soluble $P_2O_5 = .0095\%$
Total acid soluble potash $= .394\%$

As a result of soil studies in connection with our field experiments we do not expect any response from phosphate or potash fertilization from soils such as the above.

In times of low sugar prices, when careful economies are in order, in fields such as the above, it would seem best to use nitrogen only for a limited series of years or crops. Of course this cannot be carried on indefinitely, as the time will come when these soils will need phosphoric acid and potash.

Details of Experiment.

Object:

To determine which of the three main plant foods, nitrogen, phosphoric acid and potash, is lacking.

Crop:

D 1135 and Rose Bamboo, planted September 1919; harvested in January 1922.

Location:

Maui Agricultural Co., Keahua Section, field 83.

Layout:

Fifty-four plots, each 1/16 acre (63'x 69'), composed of 14 lines two watercourses long. Each plot contains two varieties and each variety occupies 7 lines two watercourses long.

Plan:

Fertilization in Pounds per Acre.

Plot	No. of Plots	November 1919			Feb. 1920	April 1920	Total		
		N.	P_2O_5	K_2O	N.	N.	N.	P_2O_5	K_2O
X	11	58.3	100	60	58.3	58.3	175	100	60
J	11	58.3	100	..	58.3	58.3	175	100	..
K	11	58.3	...	60	58.3	58.3	175	...	60
L	11	58.3	...	..	58.3	58.3	175	...	..
M	10	....	100	60	....	....	...	100	60

N. = Nitrogen, half nit. soda, half amm. sulf.
P_2O_5 = Phos. acid from acid phosphate, 16% P_2O_5.
K_2O = Potash from sulf. of potash, 48% K_2O.

EXPERIMENT NO. 9—NUMBER OF APPLICATIONS OF FERTILIZER.

In this test we tried applying a given amount of fertilizer in two, three and four applications. All plots received complete fertilizer, at the rate of 175 pounds of nitrogen, 100 pounds of P_2O_5 and 60 pounds of K_2O per acre.

The results obtained are tabulated as follows:

Variety	Treatment	Tons per Acre		
		Cane	Q. R.	Sugar
H 146	Two applications.....	40.8	9.10	4.51
D 1135 ...	Two applications.....	53.2	8.99	5.97
H 146	Three applications ..	38.9	9.22	4.22
D 1135 ...	Three applications ...	50.4	10.01	5.04
H 146	Four applications	41.8	9.57	4.37
D 1135 ...	Four applications	54.3	9.64	5.63

From the above we see that the best results were obtained when all the fertilizer was applied in two doses rather than in three or four. This is in complete accordance with our results elsewhere.

The main advantage to the application of fertilizer in few doses rather than many lies in the fact that the fertilization is finished earlier during the second season, and better juices are obtained.

Details of Experiment.

Object:

To determine the best time and number of applications in which to apply a given amount of fertilizer.

Location:

Field 83, Keahua Section.

Crop:

H 146 and D 1135 plant cane, planted September 1919; harvested January 1922.

Layot:

Number of plots: 44.

Size of plots: 1/10 acre (63'x 69'), composed of 14 straight lines each two watercourses long, or 28 single lines 4.5'x 34.5'. Each plot contains two varieties and each variety occupies 7 lines two watercourses long.

Plan:

Plot	No. of Plots	November, 1919			Feb., 1920	April, 1920	June, 1920	Total Pounds per Acre		
		N.	P_2O_5	K_2O	N.	N.	N.	N.	P_2O_5	K_2O
N	12	58.3	100	60	116.6	....	....	175	100	60
X	12	58.3	100	60	58.3	58.3	....	175	100	60
O	12	58.3	100	60	38.8	38.8	38.8	175	100	60
P	12	58.3	100	60	....	116.6	....	175	100	60

N. from 17½% nitrogen mixture, half nit. soda, half sulf. ammonia.

P_2O_5 from acid phosphate 16% P_2O_5.

K_2O from sulfate of potash = 48% K_2O.

EXPERIMENT NO. 10 — FORMS OF NITROGEN.

Equal amounts of nitrogen from various sources were compared in this test. The results obtained are summarized below:

Variety	Treatment	Tons per Acre		
		Cane	Q. R.	Sugar
Striped Mexican..	Nitrate of soda	58.0	9.61	6.04
D 1135	Nitrate of soda	56.1	9.52	5.89
Striped Mexican..	Sulf. of ammo..........................	56.0	9.26	6.04
D 1135	Sulf. of ammo..........................	56.0	9.74	5.75
Striped Mexican..	Half nitrate of soda, half sulf. of ammo.	55.0	9.02	6.10
D 1135	Half nitrate of soda, half sulf. of ammo.	53.6	9.51	5.64
Striped Mexican..	Dried blood	55.5	9.33	5.94
D 1135	Dried blood	49.8	9.22	5.40

The yields obtained were practically identical for all treatments, except that nitrogen from organic sources was not quite as good, and was the most expensive per unit.

The above is in line with results obtained at other places. The best returns are obtained where the nitrogen is in quickly available form. This holds good for the wet districts as well as the dry ones.

Details of Experiment.

Object:

To compare the value of nitrogen as: (1) Nitrate of Soda, (2) Sulfate of Ammonia, (3) Mixture of Nitrate and Sulfate, (4) Dried Blood.

Location:

Field 83, Keahua Section.

Crop:

D 1135 and Striped Mexican plant cane, planted September, 1919; harvested January, 1922.

Layout:

Number of plots: 48.

Size of plots: 1/10 acre (63'x 69'), composed of 14 straight lines two watercourses long, or 28 single lines 4.5'x 34.5'. Each plot contains two varieties and each variety occupies 7 lines two watercourses long.

Plan:

Plot	No. of Plots	Form Nit.	November, 1919			Feb., 1920	April, 1920	Total Pounds		
			N.	P_2O_5	K_2O	N.	N.	N.	P_2O_5	K_2O
Q	12	N. S.	58.3	100	60	58.3	58.3	175	100	60
R	12	S. A.	58.3	100	60	58.3	58.3	175	100	60
X	12	Nit. Sul. Mix.	58.3	100	60	58.3	58.3	175	100	60
S	12	Dried Blood	58.3	100	60	58.3	58.3	175	100	60

N. S. = 15.5% N.
S. A. = 20.5% N.
Nit. Sulf. Mix. = 17½% N. (half N. S., half S. A.).
Blood = 12% N.

The Soil Solution by Displacement.

By W. T. McGeorge.

There has recently appeared in *Soil Science* an article by F. W. Parker of the Wisconsin Experiment Station dealing with the different methods of studying the soil solution.

He divides the methods which have been used into three classes as follows:

(a) Methods involving extraction with comparatively large amounts of water,

(b) methods which aim to measure the concentration of the soil solution directly in the soil, and

(c) methods which aim to obtain the true soil solution.

The advantages possessed by the water extraction method have caused its extensive adoption as a method of studying the soil solution as well as the more available plant food. Its limitations are admitted, however, and the results obtained thereby represent the partial solvent action of water, rather than the actual soil solution. The comparative value of such data is further limited by the numerous physical and chemical factors which govern the concentration of the organic and inorganic constituents in the water extract, so that the same ratio of water to soils will not yield directly comparable extracts on all types. A ratio of one part soil to five parts water is the most widely adopted procedure, and while this ratio is more or less arbitrary it has been applied extensively to local soils.

Under the methods of measuring the concentration of the soil solution directly in the soil, attention is called to the determination of the freezing point of the soil solution and its electrical conductivity. These methods are, however, limited to the concentration and will not lead to information regarding the composition.

Methods of isolating the soil solution, itself, may be classified as follows: Centrifugal, pressure, and displacement methods. Centrifugal methods have yielded only small amounts of soil solution even in soils of high moisture content. Pressure methods, while they have been applied successfully by several investigators, require a rather complicated apparatus and yield only from soils of high moisture content. This method was tried out on Hawaiian soils by P. S. Burgess, but since there is no record of his results it is assumed that it was not adapted. While the displacement of the soil solution is not a recent idea, its practical application has apparently been revived by Mr. Parker, who has applied it with excellent results on Wisconsin soils. Its simplicity is a strong factor in its application.

In our studies on Hawaiian soils it is justifiable to assume that any method which would throw some light upon the composition of the soil solution, on which, after all, the plant is dependent for its mineral plant food supply, would be of no small value. Previous work has shown the numerous variations or fluctuations of the soil solution due to seasonal changes, fertilization, rainfall, crop growth

and biological activities. These will govern the limitations of the method as a means of determining plant food deficiencies, but it should be ideally adapted for studying soil changes. The desirability of a reliable method for determining the concentration, composition, mineral ratio, and other factors, which a knowledge thus obtained would give us, is apparent. Some time has therefore been devoted to a study of the displacement method developed by Mr. Parker as applied to Hawaiian soils.

The method consists in packing the soil in a glass cylinder or percolator. The displacing liquid is then poured on top of the soil column and as it penetrates the soil it displaces some of the soil solution which forms a zone of saturation below the displacing liquid. This is gradually forced downward until finally the soil solution drops from the soil as gravitational water.

The only apparatus required is a glass cylinder in which to pack the soil, its size depending upon the amount of soil it is desired to work or the volume of soil solution sought. In our work, glass cylinders (2″ diameter) holding 800 grams of soil and glass percolators (3¼″ x 16½″) holding 3000 grams of soil were used.

Mr. Parker compared the displacing value of several liquids, of which ethyl alcohol proved best adapted. It was therefore adopted without further study as a displacing liquid in this work.

Method of Procedure.

We have in the nitrates a soil component, which for all practical purposes may be accurately determined by extracting the soil with water. It is therefore evident that any method of separating the soil solution from the soil particles should yield a solution the nitrate content of which is comparable, when reduced to an equal basis, with that determined by extraction. Hence the nitrate determination was adopted as a means of checking the true soil solution.

In packing the soils it was found to be very essential that a uniform pack be obtained. This may be accomplished by carefully and continually tamping with a wooden rod (¾″ diameter) while the soil is being slowly poured into the cylinder. A little experience may be necessary to judge the degree of firmness which allows best percolation. This is governed by moisture content and physical texture. In the more sandy types there is no danger of puddling, but in the clay and silty loams the highest moisture content at which the soil may be squeezed in the hand without puddling seems best adapted to the conditions of the experiment, although a slightly lower moisture content permitted more rapid percolation.

The time required for complete displacement varied from three hours in a sandy loam to approximately one week in a heavy clay. The time of displacement in the clays was decreased to as little as twenty-four hours by working at lower moisture content. The solution obtained requires no filtration, being perfectly clear, clouding rapidly, however, on standing, due to absorption of carbon dioxide from the air.

Eleven soils, representing a wide range of Island types, were used in this work. Total soluble solids was obtained by evaporating 50 cc. of the soil solu-

tion to dryness in a platinum dish and nitrates coloremetrically by the phenol-disulphonic acid method, using 10 cc. of the soil solution.

Results are given in the following table and are calculated to parts per million solids and nitrates in the moisture free soil. Moisture content of the soil is also given to show the amount present in the soil as used.

TABLE I.

TABLE SHOWING VARIATION IN CONCENTRATION OF SOIL SOLUTION AND COMPARING NITRATES BY DISPLACEMENT AND EXTRACTION.

Soil	Total solids p. p. mil water free soil	Nitrates p. p. mil by displacement	Nitrates p. p. mil by extraction	Per cent moisture in soil
1. Maui Agri. (red clay)	150	8.5	8.7	20.0
2. Oahu Field 45 (red clay)	184	7.9	8.1	24.4
3. Pioneer (red clay)	75	4.0	3.9	22.4
4. Station soil (brown silt)	157	5.2	4.9	20.0
5. Hakalau (yellow clay)	249	1.3	3.9	45.6
6. Onomea (yellow clay)	337	Trace	8.1	36.8
7. Hilo Sugar (yellow clay)	200	3.6	6.6	44.4
8. Hilo Sugar (yellow clay)	322	3.5	6.5	43.8
9. Honolulu Plant. (red clay)	593	21.6	26.5	28.0
10. Waialua (red silt)	421	25.1	31.7	31.0
11. Honokaa (silty sand)	169	15.7	14.6	31.0

The results, with the exception of soils numbers 5 to 8 inclusive, as judged by the nitrate content, indicate the true soil solution to have been obtained. The exceptions are of the yellow clay type which predominates in the Hamakua coast district on Hawaii, possessing high moisture content and high degree of hydration. Two possible explanations of the results obtained suggested themselves. Either the true soil solution was not obtained in these soils or nitrates were lost during displacement by denitrification.

Since these soils were packed very tightly and percolation was extremely slow, loss of nitrate appeared the most plausible explanation. In order to test this out, nitrate determinations were made at different depths in soil number 7 as taken from the glass cylinder about one week after displacement had been completed. The top layer, dried out, showed a faint trace of nitrate, probably from subsequent nitrification, while no nitrate was present in the lower depths, indicating that the nitrates had entirely disappeared during the displacement.

In order further to prove this, three soils, a sandy loam, a silty loam, and a clay loam, all high in nitrates, were packed in percolators and alcohol was poured on top of the soil. Nitrate determinations were made on the first portions of the displaced solution and the last portion preceding that in which alcohol contamination was apparent. In the sandy soil, displacement was complete in three hours, 300 cc. from 2000 grams or 49% being obtained. Both the first and last portions checked exactly, 15.7 parts per million nitrogen as nitrate. However, this soil solution, on standing in a tightly corked flask two days, decreased in

nitrate nitrogen from 15.7 to 8.5 parts per million. The other two soils percolated more sluggishly, the silty loam yielding 250 cc. in two days and the clay loam 150 cc in two days. The analysis of the first and last portions as above showed the former to have dropped from 25.1 p. p. m. in the first portion to 0.94 p. p. m. in the last, while the clay dropped from 26.5 to 0.19 p. p. m.

These results clearly prove the discrepancies in Table I to be due to denitrification, and indicate that where the nitrate determination is used as a check, determinations should be made only on the first portions of the displaced solution in all cases where displacement is sluggish.

In view of these promising results the work was further extended to compare results obtained by the water extraction methods and the soil solution by displacement. Extractions were made using ratios of 1:1, 2:5, and 1:5 parts soil to water. Soil and water of the above proportions were shaken for three hours in a shaking machine, filtered through Pasteur tubes and total solids determined by evaporating 50 cc. of the filtrate to dryness on the steam bath. The results are given in Table II, calculated to and comparing p. p. m. water free soil and in the solution obtained. It will be noted that there is considerable variation, but in most cases an extraction ratio of 1:1 dissolves amounts of solids closely related to that of the soil solution if both are calculated in terms of water free soil. This does not apply universally, for the reason that extraction methods, regardless of solvent, will vary on the different soil types, depending upon certain chemical and physical influences.

TABLE II.

COMPARING EXTRACTION AND DISPLACEMENT.

Soil	(P. p. mil. water free soil)				(P. p. mil. in solution)				H_2O in Soil
	1 : 1	2 : 5	1 : 5	Disp.	1 : 1	2 : 5	1 : 5	Disp.	
Oahu Field 45	194	100	92	572	211	298	639	184	24.4
Pioneer	104	80	48	300	113	235	323	75	22.4
Station soil	154	119	94	630	160	342	611	157	20.0
Hakalau	166	136	128	298	199	481	1292	249	45.6
Onomea	142	100	64	580	163	229	544	337	36.8
Hilo Sugar	198	152	90	350	237	532	884	200	44.4
Hilo Sugar	142	94	68	254	170	327	679	322	43.8
Honolulu Plantation ..	488	274	232	1524	547	842	1702	593	28.0
Waialua	286	170	82	936	324	535	681	421	31.0
Honokaa	160	90	60	376	181	283	461	169	31.0

Discussion and Value of Method.

These results, it is believed, prove that the displacement method, using ethyl alcohol as the displacing liquid, gives the true soil solution with Hawaiian soils. It can be used at a wide range of moisture content, and in those cases in which data were collected to show the per cent recovery a variation of 16 to 60 per cent of the water present in the soil was recovered. The maximum recovery

is possible in all cases in which careful note of and allowance for moisture is made. The puddled condition resulting from working soils of too high moisture content was in extreme cases found to prohibit displacement entirely.

The data in Table I indicate a wide variation in the concentration and composition of the soil solution in Hawaiian soils. Apparently lime is an important factor, as the highest concentration is noted in the high lime and the lowest in the low lime soils.

Further data are submitted in Table III, showing the variation in lime, potash and phosphoric acid in seven soils and three subsoils. The results are expressed in parts per million in water free soil and are submitted simply to illustrate variations. Comment must necessarily be reserved for further accumulation of data. However, attention is called to the low phosphoric acid figures and the high potash results obtained on the high lime soils.

TABLE III.

SHOWING CaO, K_2O AND P_2O_5 IN DISPLACED SOIL SOLUTION CALCULATED P. P. MIL. H_2O FREE SOIL.

	Lime CaO	Potash K_2O	Phosphoric Acid P_2O_5
Waimanalo soil	35.6	23.2	.6
Waimanalo subsoil	28.2	16.3	Trace
Waimanalo soil	11.9	9.5	1.3
Waimanalo subsoil	6.9	2.3	Trace
Waimanalo soil	38.9	4.1	Not det.
Oahu soil	24.3	16.5	.9
Honokaa subsoil	12.1	10.8	Trace
Honolulu Plantation soil	62.3	19.0	3.3
Waialua soil	41.0	22.9	.3
Hakalau soil	54.1	21.0	Not det.

We know that the soil solution is saturated only with respect to the particular system existing at any given time, that it is constantly undergoing modifications of sufficient proportions to require an examination of the soil solution at frequent intervals in order to derive complete value from the analyses. The wide variation in concentration, however, to be noted in Tables I and III, indicate a possible value as a means of ascertaining in a limited way plant food deficiencies in our soils. An extensive comparison of the soil solution from good and poor fields would be necessary to answer this.

Its principal value appears to lie in its adaptation to studying soils in which toxic constituents are suspected and those in which a knowledge of the changes in plant food due to plant growth, fertilization, rainfall, irrigation, etc., is desired. In order to illustrate, a series of samples taken from Experiment 6, Oahu Sugar Co., field 45 (an upland red clay soil), were treated by the displacement method given above. In this experiment all plots have received the same potash and nitrogen application—namely, 60 pounds potash from muriate and 150 pounds

TABLE IV.

COMPARING CONCENTRATION OF SOIL SOLUTION FROM EXPERIMENT 6, OAHU SUGAR CO.

	X Plots			A Plots				B Plots				C Plots			
Moisture in soil	24.6	24.0	25.2	24.0	23.2	24.2	23.8	24.2	23.8	22.8	24.6	22.6	23.4	23.8	24.0
Parts per million solids in soil solution.	358	358	350	430	361	446	458	444	400	418	360	418	386	410	360
Average	355			424				405				395			

TABLE V.

SHOWING LIME, POTASH AND TOTAL SOLIDS IN PARTS PER MILLION WATER FREE SOIL.

	X Plots	A Plots	B Plots	C Plots
Lime (CaO)	6.65	12.06	8.82	7.78
Potash (K_2O)	11.3	7.95	8.11	8.55
Total Solids	113.9	133.5	127.7	124.4

nitrogen from sodium nitrate per acre. In addition the X plots received no phosphoric acid, the A plots 180 pounds phosphoric acid per acre from reverted phosphate, the B plots 90 pounds from reverted phosphate, and the C plots 90 pounds from acid phosphate. Fertilizer was applied in February, 1921, with an additional dose of nitrogen only in May, 1921. The soil samples were taken in December, 1921, ten months after the application of the fertilizer. The cane was approximately one year old from second ratoons. All plots were thoroughly sampled in order to obtain a representative sample. The analyses are given in Tables IV and V, the total solids being determined separately as shown in Table IV, and the soil solutions from similar plots combined for the determination of potash and lime.

The data presented here are very concordant and illustrate very clearly the value of the method for studying fertilizer applications. There is practically no difference in the moisture content of the samples from the sixteen plots, a very fortunate circumstance in comparing the concentration of the soil solution as obtained from this series. Variation in total solids agrees very closely with fertilizer applications. The lime in solution is as would be anticipated, also. The phosphate results showed a very low concentration, only a trace being indicated in the colorimetric determination. All plots received the same potash application and the higher concentration in the X plots may be due to the poorer growth made in the plots to which no phosphoric acid was applied with the accompanying lower drain on the soluble plant food.

In applying the method to a comparison of the relative concentration of the soil and subsoil solutions, three soils with their respective subsoils were treated with alcohol as above and the determinations given in the following table were made.

TABLE VI.

SHOWING TOTAL SOLIDS AND LIME IN SOIL AND SUBSOIL SOLUTION, P. P. M. WATER FREE SOIL.

	Water in Soil	Total Solids	Lime CaO
1. Brown clay soil	20.0%	133	11.9
1. Brown clay subsoil	25.0%	65	6.9
2. Dark greyish clay soil	24.0%	262	38.9
2. Dark greyish clay subsoil	24.8%	241	39.1
3. Red clay soil	21.0%	292	35.6
3. Red clay subsoil	29.0%	230	28.2

Little comment on the above is necessary. The results are as would be anticipated in comparing soil and subsoil, namely, a lower concentration in the subsoil solution.

CONCLUSIONS.

1. Using ethyl alcohol as a displacing liquid, the true soil solution may be obtained from Hawaiian soils.

2. In a majority of the soils used, the displacement method gives approximately the same amount of total salts as a 1:1 extraction with distilled water.

3. The method is especially adapted to a study of the composition of the soil solution as influenced by fertilization, plant growth, irrigation, temperature and other factors and for studying variations between good and poor fields.

4. The principal limitation lies in the taking of the soil sample. If the soil at time of sampling is too wet it becomes puddled thereby and its proper packing in cylinders for displacement is impossible. Drying out in the laboratory after bringing from the field is impractical, due to the increase in the solubility of the soil constituents resulting therefrom. It is therefore essential that attention be given to this point.

Nitrogen Gives Results at Lihue.

LIHUE PLANTATION CO.—EXPERIMENT 5, 1922 CROP.

This is an experiment to determine the economic limit in nitrogen application on plant cane at Lihue. It is of unusual significance and importance since beneficial results were obtained here on plant cane on land very similar to neighboring Grove Farm fields, situated at about the same elevations, in which the plant cane did not respond to nitrogen.

These differences in response to nitrogen fertilization are probably due to the fact that Grove Farm fields are pastured and green fallowed for three years between cane crops.

The cane was Yellow Caledonia, planted in April, 1920, and cut back in July.

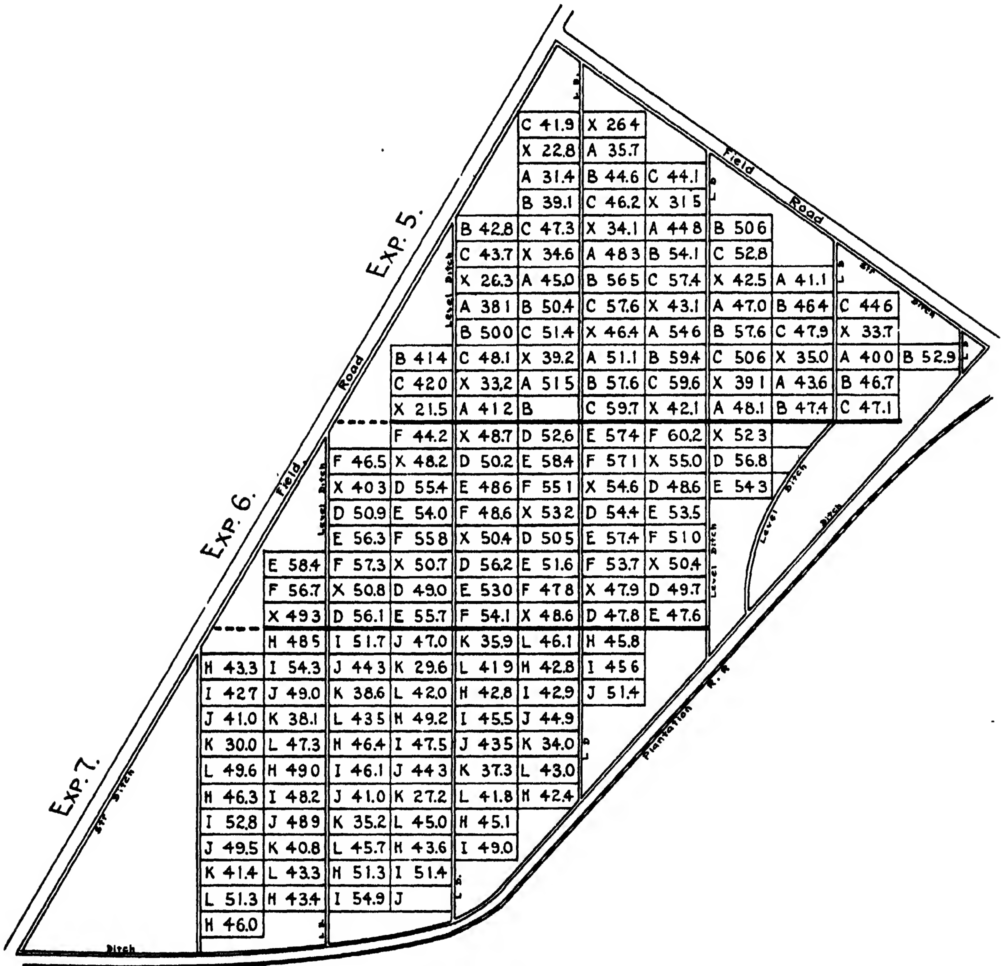
A uniform dose of 240 pounds of molasses ash per acre was applied to all plots in July, 1920, and a uniform dose of 500 pounds of reverted phosphate was applied to all plots the first of August.

It was originally intended to apply the nitrogen in three equal doses in August, January, and March. It was necessary to change this plan, however, and the first dose was applied in October, 1920, and the other two doses were combined and applied the last of February, 1921.

Exp. 5. Amount Of Nitrogen.
Exp. 6. Amount Of Phosphoric Acid.
Exp. 7. Plant Food Requirements.

Lihue Plantation Co. Expts. 5,6 & 7, 1922 Crop

Field 13.



Summary Of Results

Exp. 5.

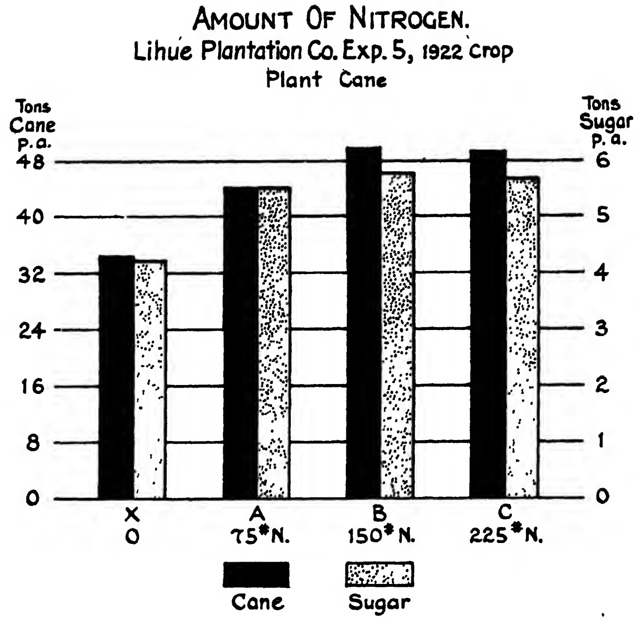
Plots	No. of Plots	N	P_2O_5	K_2O	Yields Per Acre: Cane	Q.R.	Sugar	Gain or Loss Over X Plots: Cane	Sugar
X	16	0	70	60	34.44	8.1	4.25		
A	15	75	70	60	44.08	8.0	5.51	+ 9.64	+ 1.26
B	17	150	70	60	49.82	8.6	5.79	+15.38	+ 1.54
C	17	225	70	60	49.51	8.7	5.69	+15.07	+ 1.44

Exp. 6.

Plots	No. of Plots	N.	P_2O_5	K_2O	Yields Per Acre: Cane	Q.R.	Sugar	Gain or Loss Over X Plots: Cane	Sugar
X	14	150	0	60	49.99	8.0	6.25		
D	13	150	70	60	52.15	8.2	6.36	+ 2.16	+0.11
E	13	150	140	60	54.30	8.5	6.39	+ 4.31	+0.14
F	13	150	210	60	52.91	8.5	6.23	+ 2.92	-0.02

Exp. 7

Plots	No. of Plots	N.	P_2O_5	K_2O	Yields Per Acre: Cane	Q.R.	Sugar	Gain or Loss Over H Plots: Cane	Sugar
H	15	150	0	0	45.71	7.8	5.86		
I	13	150	70	0	48.63	7.7	6.32	+ 2.92	+0.46
J	12	150	0	60	45.85	7.8	5.88	+ 0.14	+0.02
K	11	0	70	60	35.26	7.6	4.64	-10.45	- 1.22
L	12	150	70	60	45.02	7.8	5.77	- 0.69	- 0.09



In addition to the potash and phosphates applied the amounts of nitrogen applied are given in tabular form as follows:

Nitrate of Soda per Acre.

Plot	No. of 1/10 Acre Plots	October	February	Total Nitrogen
X	16	...	...	...
A	15	161	323	75
B	17	323	646	150
C	17	484	968	225

The harvesting results obtained from this experiment were as follows:

Summary of Results.

Plot	Nitrogen per Acre	Yields per Acre			Gain or Loss Over X Plots	
		Cane	Q. R.	Sugar	Cane	Sugar
X	...	34.44	8.1	4.25	....	....
A	75	44.08	8.0	5.51	9.64	1.26
B	150	49.82	8.6	5.79	15.38	1.54
C	225	49.51	8.7	5.69	15.07	1.44

In this experiment there was a decided gain, both in cane and in sugar from 75 pounds of nitrogen. While an additional 75 pounds of nitrogen per acre appreciably increased the amount of cane, the quality of the juice was low-

ered and the resulting increase in sugar was not so marked as with the first 75 pounds. Increasing the nitrogen to 225 pounds gave no further increase in cane, and lowered the quality of the juices slightly.

Details of Experiment.

Object:

To determine the economic limit of nitrogen to apply as nitrate of soda under conditions at Lihue Plantation Co.

Location:

Field 13.

Crop:

Yellow Caledonia, plant.

Layout:

Number of plots: 65.

Size of plots: 1/10 acre (40.3'x 108'), composed of 24 straight lines one watercourse long.

Rows 4.5' wide and 40.3' long.

Plan:

Fertilization — Pounds per Acre.

Plots	No. of Plots	May, 1920		October, 1920		N. S. Feb.,	Total Nitro.
		R. P.	M. A.	N. S.	N. S.	1921	
X	16	500	240	...	...	...	...
A	15	500	240	161	...	323	75
B	17	500	240	323	...	646	150
C	17	500	240	484	...	968	225

Fertilizer — Nitrate of Soda: 15.5% N.
Experiment planned by J. A. Verret, R. S. Thurston and J. H. Midkiff.
Experiment laid out by R. S. Thurston and J H. Midkiff.
Experiment fertilized and harvested by J. H. Midkiff.
Chemical analyses by B. Henderson.

J. H. M.

Phosphate Experiment at Lihue.

LIHUE PLANTATION COMPANY — EXPERIMENT 6, 1922 CROP.

This experiment was designed to determine the value of phosphate on land lying through the central part of Lihue Plantation. It is neither in the mauka section of the plantation, where it is generally conceded that phosphates give results, nor in the makai section, where phosphates are generally thought to be unneeded.

The cane was Yellow Caledonia, planted in April 1920, and cut back in July.

A uniform dose of 240 pounds per acre of molasses ash was applied to all the plots in July 1920. All plots received nitrogen in nitrate of soda applied at the rate of 150 pounds of nitrogen, or 968 pounds of nitrate of soda, per acre.

The reverted phosphate was applied in the line to the cane in August, soon after the cane started to send its shoots up after the cutting back.

A summary of the fertilizer applications follows:

Fertilizer per Acre.

Plots	Rev. Phos. August	Molasses Ash	Nitrate of Soda — October	Nitrate of Soda — February
X	....	240	323	646
D	500	240	323	646
E	1,000	240	323	646
F	1,500	240	323	646

The harvesting results obtained from this experiment were as follows:

Plots	No. of Plots	Treatment P_2O_5	Treatment N.	Treatment K_2O	Yields per Acre Cane	Yields per Acre Q. R.	Yields per Acre Sugar	Gain or Loss Over X Plots Cane	Gain or Loss Over X Plots Sugar
X	14	...	150	60	49.99	8.0	6.25	......	......
D	13	70	150	60	52.15	8.2	6.36	+ 2.16	+ 0.11
E	13	140	150	60	54.30	8.5	6.39	+ 4.31	+ 0.14
F	13	210	150	60	52.91	8.5	6.23	+ 2.92	— 0.02

In this experiment all applications of phosphates gave small increases in cane, although 500 pounds of reverted phosphate gave practically the same increase in cane as 1500 pounds.

While these gains are small, the need for phosphates is shown, and we feel that they should be added. We believe that the phosphate needs of this soil are now taken care of by the P_5O_2 in the high grade fertilizer used, and that no extra applications are called for.

Details of Experiment.

Object:

To determine the value of applying reverted phosphate under conditions at Lihue Plantation Co.

Location:

Field 13.

Crop:

Yellow Caledonia, plant.

Layout:

Fifty-three plots, each 1/10 acre (40.3'x 108'), composed of 2 4straight lines one watercourse long. Rows 4.5' wide and 40.3' long.

Fertilization — Pounds per Acre.

Plots	No. of Plots	Lbs. of Rev. Phos. Aug., 1920	Aug. M. A.	Oct. N. S.	Feb. N. S.	Total N.
X	14	....	240	323	646	150
D	13	500	240	323	646	150
E	13	1,000	240	323	646	150
F	13	1,500	240	323	646	150

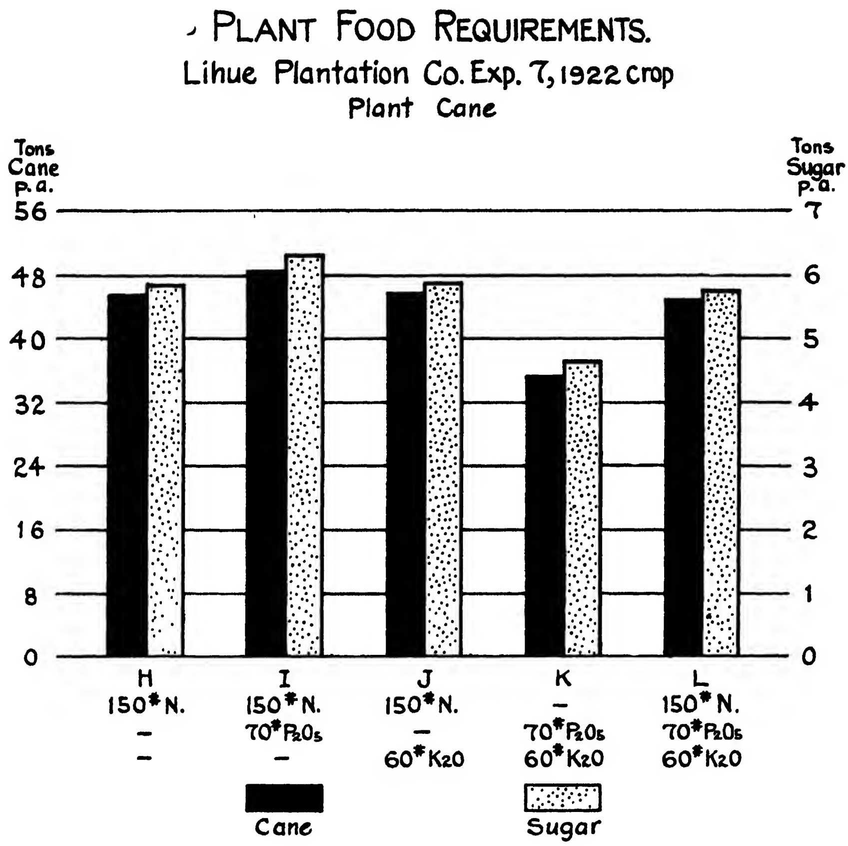
Experiment planned by J. A. Verret, R. S. Thurston and J. H. Midkiff.

Experiment laid out by R. S. Thurston and J. H. Midkiff.

Experiment fertilized and harvested by J. H. Midkiff.

Juice analyses by B. Henderson.

J. H. M.



Plant Food Experiment at Lihue.

LIHUE PLANTATION CO.—EXPERIMENT 7, 1922 CROP.

This is a plant food experiment to determine the value of nitrogen, phosphates and potash. Like Experiment 5 in the same field, it tests the value of nitrogen; like Experiment 6, it deals with phosphates. In addition it checks on the value of potash under these conditions.

The cane is Yellow Caledonia, planted April 1920, cut back in July.

The molasses ashes and the reverted phosphate were applied to the cane soon after it had begun to send out its new shoots after cutting back. The nitrogen was applied in October 1920, and February 1921.

The fertilizer applications are given in tabular form as follows:

Plots	Pounds per Acre			
	July	August	October	February
H	....	....	323 N. S.	646 N. S.
I	....	500 R. P.	323 N. S.	646 N. S.
J	240 M. A.	....	323 N. S.	646 N. S.
K	240 M. A.	500 R. P.	....	....
L	240 M. A.	500 R. P.	323 N. S.	646 N. S.

The results obtained from harvesting this experiment are as follows:

Plots	Yields per Acre			Gain or Loss Over Check H Plots	
	Cane	Q. R.	Sugar	Cane	Sugar
H	45.71	7.8	5.86	......	......
I	48.63	7.7	6.32	+ 2.92	+ 0.46
J	45.85	7.8	5.88	+ 0.14	+ 0.02
K	35.26	7.6	4.64	— 10.45	— 1.22
L	45.02	7.8	5.77	— 0.69	— 0.09

Checking closely with the results of Experiment 5, the addition of 150 pounds of nitrogen gave an increase of approximately one and one-quarter tons of sugar per acre. Like Experiment 6, the addition of 500 pounds of reverted phosphate per acre gave a slight increase in cane. In this experiment the juice was not lowered by the addition of phosphate and nearly half a ton more sugar per acre resulted from the phosphate application. Potash apparently had very little effect in the yield of cane or sugar, the differences in the yields being within the limits of experimental error.

Details of Experiment.

Object:

To determine the plant food requirements of sugar cane under condition at Lihue Plantation Company. Comparisons are made between:

1. Nitrogen.
2. Nitrogen and Phosphoric acid.
3. Nitrogen and Potash.
4. Nitrogen, Phosphoric Acid and Potash.
5. Phosphoric Acid and Potash.

Location:

Field 13.

Crop:

Yellow Caledonia, plant.

Layout:

There were 63 plots, each 1/10 acre (40.3'x 108'), composed of 24 straight lines one watercourse long. Rows 4.5' wide and 40.3' long.

Plan:

Fertilization — Pounds per Acre.

Plots	No. of Plots	July, 1920			Jan., 1921	March, 1921	Total Pounds		
		N. S.	R. P.	M. A.	N. S.	N. S.	N.	P_2O_5	K_2O
H	15	323	...	...	323	323	150	...	...
I	13	323	500	...	323	323	150	70	...
J	12	323	...	240	323	323	150	...	60
K	11	...	500	240	...	...	...	70	60
L	12	323	500	240	323	323	150	70	60

N. S. = 15.5% N. R. P. = 14% P_2O_5. M. A. = 25% K_2O.
Experiment planned by J. A. Verret, R. S. Thurston and J. H. Midkiff.
Experiment laid out by R. S. Thurston and J. H. Midkiff.
Experiment fertilized and harvested by J. H. Midkiff.
Analyses of juice samples by B. Henderson.

J. H. M.

Something About Separators.*

By W. H. Wakeman.

Three modern high-speed engines were used to supply power for a certain manufacturing plant. They were removed and replaced by three turbines. The sole reason for the exchange was that all exhaust steam was wanted for use in the works, but inasmuch as the exhaust contained more or less cylinder oil on coming from the engines, the turbines were adopted, because they used no cylinder oil.

A dealer claims that he supplied one separator to another plant, with the expectation of furnishing more provided the first removed all cylinder oil from the exhaust steam and the others were delivered in due time. If it was possible to secure this result in one case, why could it not have been done in the other? Changing the prime movers was much more expensive than it would have been to install separators. If there was any difference in the steam consumption, it had no weight in arriving at a decision in this case, because all exhaust steam was used to advantage in manufacturing processes. Several other dealers in separators claim to secure practically the same results. Why are failures along this line frequently found?

One reason is because some cylinder oils are much more viscous than others. As this quality may be defined as "sticky," it means that some kinds excel others in cleaving to the iron surface with which they come in contact, hence if a certain separator does not remove all the oil, a simple and inexpensive experiment may be tried by substituting other brands of oil until better results are secured or the separator is proved to be responsible for the failure.

The chief engineer of a mill found that the exhaust steam from his engine contained oil. The separator was located next to the engine and beyond it, a feed water heater. When the location of these two appliances was changed to that illustrated in Fig. 1, the cylinder oil was removed from the exhaust steam, and this was the only change made. The philosophy of the operation and succeeding practice is that when cold water was pumped into the heater and a portion of the steam condensesd in the process of heating the water, the resulting drops of water combined with the particles of oil, and as the mixture became heavier than the steam, it was readily separated from it by centrifugal force; hence, the better results secured.

*From "Power," November 15, 1921.

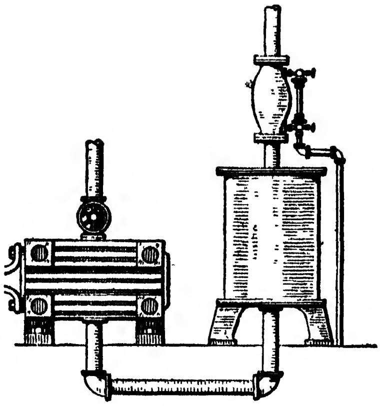


FIG. 1

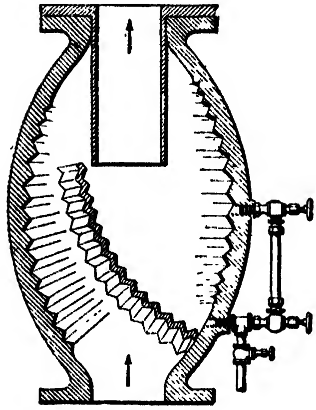


FIG. 2

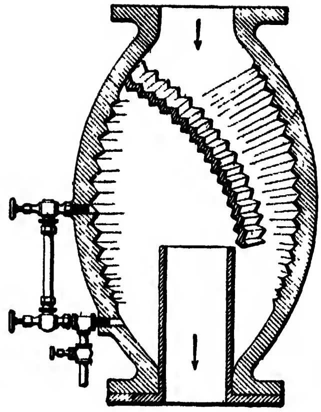


FIG. 3

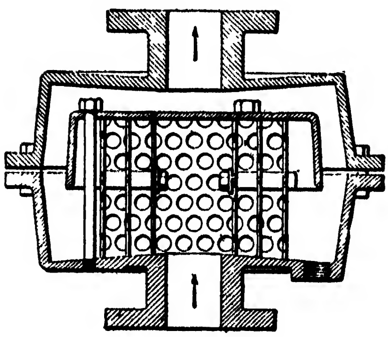


FIG. 4

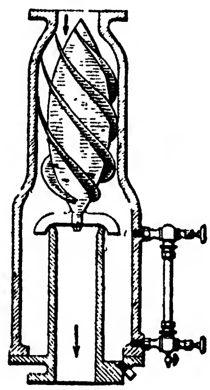


FIG. 5

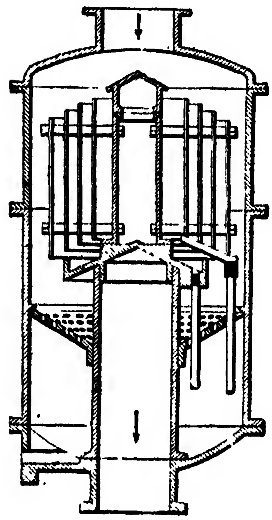


FIG. 6

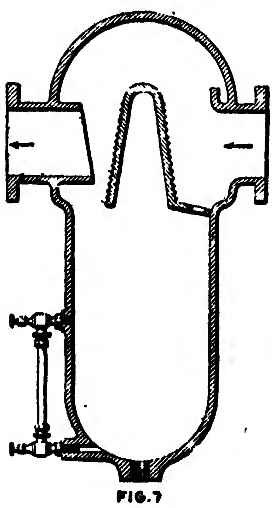


FIG. 7

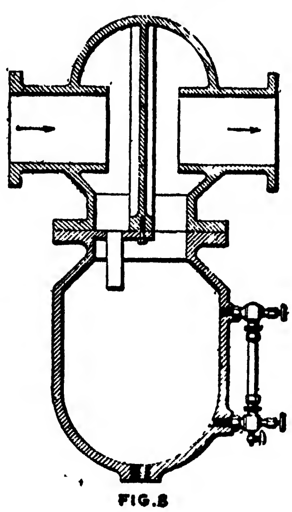


FIG. 8

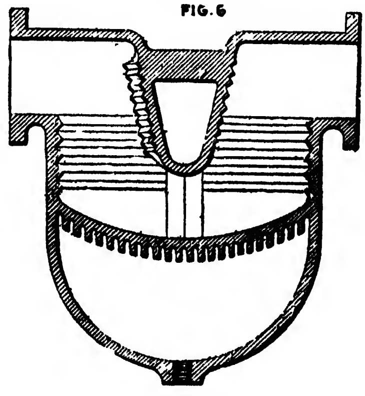


FIG. 9

Fig. 1—Separator placed above the heater gave better results than when placed next to the engine. Fig. 2—Steam enters at the bottom of the separator. Fig. 3—Same type of separator design with steam entering at the top. Fig. 4—Another separator in which the steam should pass upward. Fig. 5—Steam flow is downward. Fig. 6—Steam can flow in either direction. Fig. 7—Horizontal separator, steam entering at the right. Fig. 8—Separator with inlet connection at the left. Fig. 9—Steam can flow in either direction.

Separators should be placed as their makers intended that they should be. A good illustration of this necessity is shown in the following. Steam should pass upward through Fig. 2 and downward through Fig. 3. If the direction of the flow in either case is reversed, the best results cannot be expected. Where this design of separator is ordered direct from the manufacturers and working conditions are specified, they will be sent accordingly, but as time passes and changes in the piping are made, they may be put out of service. Later on, when required for other places, they may be installed so that the direction of flow is not the same as formerly. This is more likely to happen because the castings are practically the same, but that does not prove that they are interchangeable.

Fig. 4 illustrates a separator that should be located as shown, with steam passing upward through it. Fig. 5 shows a design that is not so likely to be mistaken as some other types. The curved deflecting plates must perform the separating function when the steam first enters the separator, and the reservoir must be located at the lower point; hence, steam flows downward and the oil and water go out through a suitable drip pipe.

If steam and oil pass upward through the type of separator shown in Fig. 6, some of the oil will be taken out, but the results will be more satisfactory if the direction of flow is downward.

Fig. 7 shows a horizontal separator with the inlet at the right and the outlet at the left. Fig. 8 shows a similar device, but the direction of flow is from left to right hand. If good results are desired, these directions of flow must be followed, but if it is necessary to use either one for a direction of flow that is opposite to the illustrations, it may be done by turning the separator around. In this respect a horizontal differs from a vertical separator, as the former can be reversed at pleasure to meet the direction of flow. However, care should always be taken to have the steam enter as the makers intended.

Fig. 9 is designed for steam flowing in either direction, and it does not make any difference which way it is connected.

[W. E. S.]

Studies in Indian Sugar Cane, No. 4.*

Morphological Considerations.

(Abridged.)

By C. A. Barber.

As we work with the sugar cane plant in attempting to guide its variabilities to suit our purposes, any precise information such as that furnished by C. A. Barber and his collaborators in India becomes distinctly helpful.

(1) Early Stages of Seedlings and Sprouted Cuttings.

Before proceeding to the description of branching in the sugar cane, it will be advisable to get some idea as to the various stages by which the plant, as we see it, is built up. For this purpose I have put together observations and drawings, which have been made at different times during the past five years, on the germination of the cane seed and the sprouting of the sets, as these will form a useful basis for our study.

The seed of the sugar cane is extremely minute, the average length being 1.5 mm. and its breadth one-third of that amount. Strictly speaking, it is not merely a seed, but a fruit or caryopsis, for, as in all grasses, there is only one seed in the ovary, and its walls are fused with those of the fruit to an indistinguishable mass. The embryonic plant lies obliquely across one end of the seed, the rest being taken up by a mass of starch-bearing cells, the endosperm, a reserve of food for the early stages of growth. On comparing the relative sizes of germ and endosperm, the sugar cane appears to be poorly equipped with the latter, as, before the young plant protrudes from the seed-coats, it occupies in the vertical section nearly half of the space available. Considering the small size of the seed itself, there is thus very little food laid by for the initial stages of growth before it becomes independent; the cane seedling is excessively small and its growth is not nearly so rapid as the cultivated grains, and, indeed, as the grass weeds which infest the seedling pans. The sugar cane in fact reminds us of the proverbial "mustard seed" in the smallness of its seed and the comparatively enormous size of the full grown plant. As a natural result of this, the seed of the sugar cane cannot be kept for long, although our series of observations, carried on for some years, show that its vitality is greater than previously supposed, and is not the same in all varieties.

The general course of development may be gathered from the accompanying figures, firstly, of microtome sections through resting and germinating seeds (Pl. I), and, secondly, of drawings made from outside (Pls. II, III, and IV). There is little in these Plates which calls for special attention, as the general course agrees with that in grasses and has been sufficiently described in textbooks. In the cases of *Karun* seedlings which have been examined (Pl. III),

* From Memoirs of the Department of Agriculture in India, Botanical Series, Vol. X, p. 46.

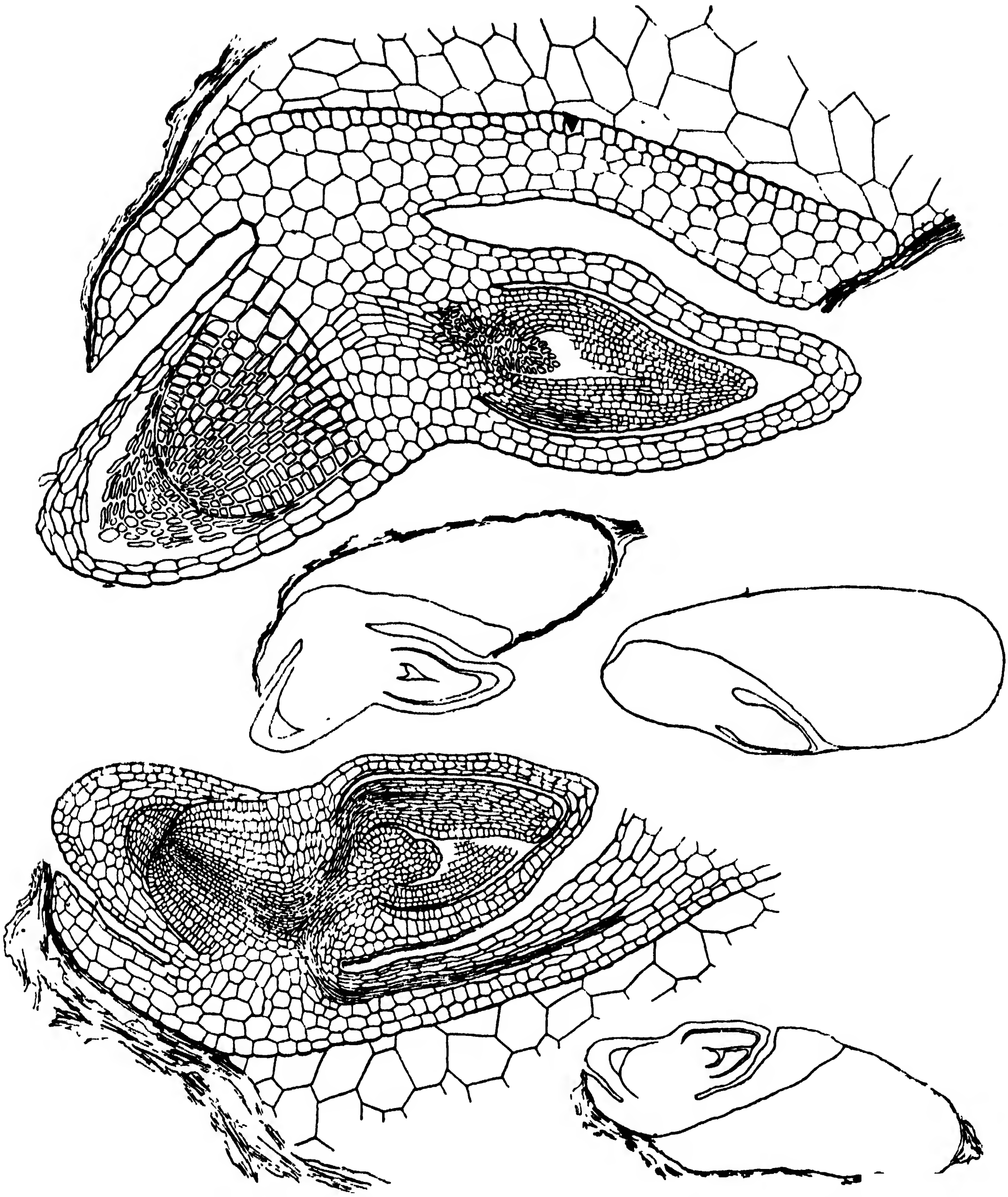


Plate I. Microtome sections through resting and germinating seeds of sugar cane. Madras Seedling No. 6.

there is an elongation of the plumule axis below the first leaf, similar to that in the wheat, presumably designed to place the young plant clear of its seed-coats and near to the surface of the ground, for the purpose of tillering, and I have reproduced a drawing from Percival's *Agricultural Botany* to make this clearer. But in the *Karun* seedlings a thickish root is given off from this elongated part of the stem which I have not seen figured elsewhere.

The purpose of this early root formation appears to be obvious enough, namely, to reinforce at the earliest possible moment the small amount of available stored material at the disposal of the young plant. The radicle with its

first root has, as usual, a merely temporary existence, or lingers for some time as a minute fiber which can have little effect in aiding the plant in its growth. After this preliminary arrangement of the parts of the seedling has been concluded, the plumule develops its leaves in rapid succession and, near their bases, a series of thick adventitious roots are soon produced; but the seed-coats, with the plug-like sucker, the elongated plumule axis and its first adventitious root, remain attached to the plant for a considerable time, as they have been detected in a *Karun* seedling already five inches above ground. Different stages in this development are given on Plates II, III, and IV.

The leaves are formed in one plane, alternately on either side of the stem, and the whole young plant may thus be pressed flat with all its parts spread out. At a very early stage of development a bud is formed in the axil of each leaf, so that branches, as well as leaves, all arise in the same plane. The formation of successive leaves, one at a time, has the effect of dividing the stem into a series of segments, each provided with one leaf and one bud. These segments are usually termed joints, and it is the practice to regard the joint as bearing its leaf and bud at its lower end, being thus terminated above and below by a leaf, and, when this has withered and fallen, by the sharp ridge or leaf scar which completely surrounds the stem. The region where the joints are separated is termed the node or knot, as it is usually more or less swollen, and the joint as defined above thus becomes the internode.

An appropriate arrangement of the fibrovascular bundles within the stem has meantime taken place, and this can be very well seen in longitudinal sections; namely, while the bundles run parallel with the length of the stem in the internodes, they form an intricate, wefted mass at the node, and branches are given off to the leaves and roots at this point. This arrangement of the bundles takes place very early in the development, and it is thus easier to demonstrate the limits of the first formed joints by viewing them in a longitudinal section than from the outside (Pl. VI, fig. 1C). The region of root formation is at the base of each joint, above the origin of the leaf, and consists of a narrow ring of the surface where the nascent roots may be seen as two or three rows of dots; this is termed the root zone. In parts of the stem beneath the level of the ground these root primordia quickly grow out and, perforating the leaf bases, form a mass of roots which, with their branchings and root hairs, leave no particle of soil untapped. The first formed joints are extremely short, being in the form of narrow superposed discs, and the leaves borne by them are therefore very close together. The joints are, moreover, extremely thin at first, but increase in thickness upwards, the successive leaves and roots providing material for their expansion, so that, as in many Monocotyledons, a longitudinal section of the stem at the base shows its form to be that of an inverted cone (Pl. IV, fig 1d). The leaves, growing much more rapidly than the stem, increase in width at the base and encircle a larger portion of the circumference of the stem until their edges overlap.

The further development of the plant proceeds on strictly similar lines. The main points to be held in view are the upward increase in thickness of the stem, the protrusion of the buds from the leaf axils, the increasing number and thickness of the roots developed on successive joints, the continual lengthening

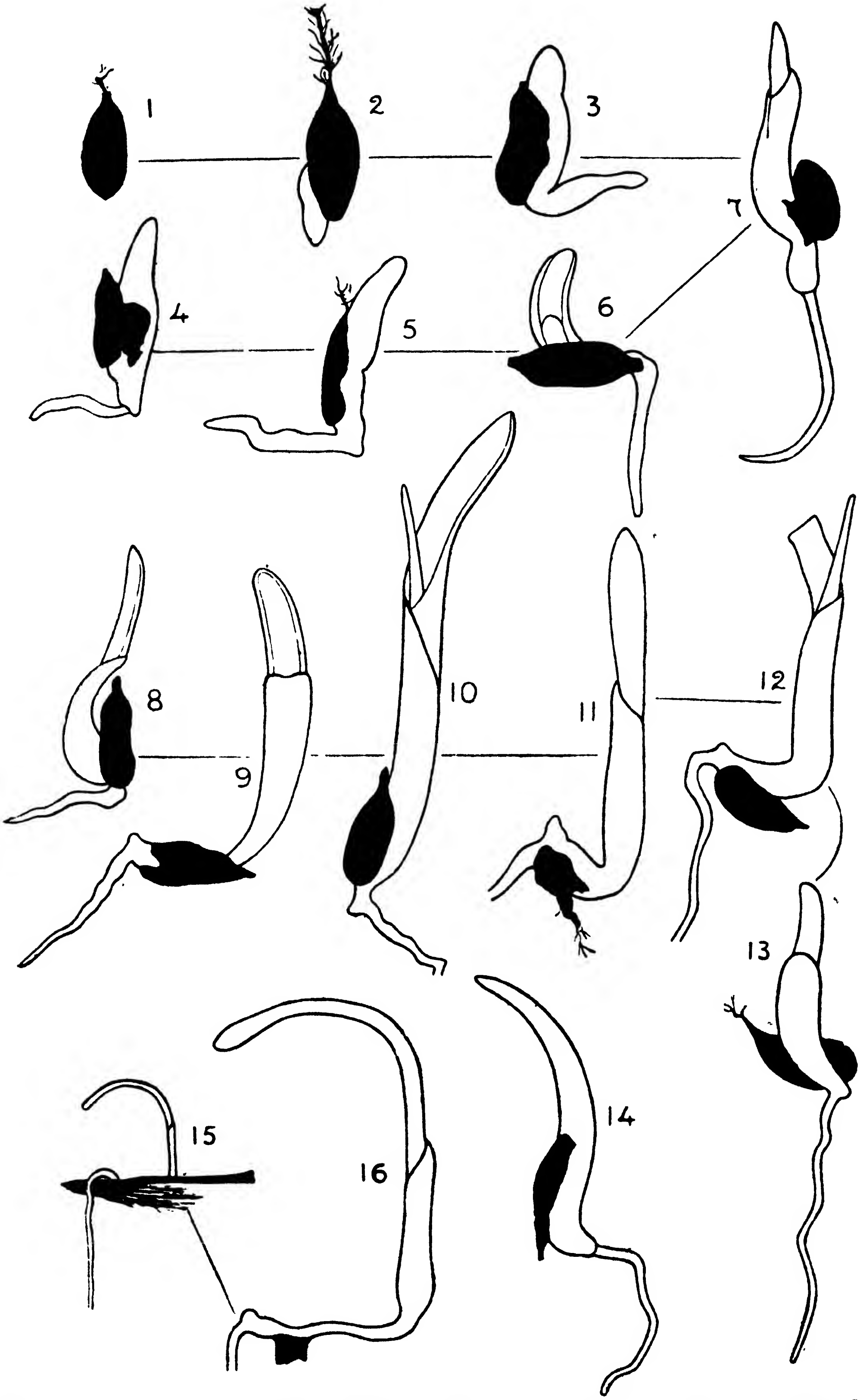


Plate II. Germinating seedlings of Kassoer; figs. 1–7, four days old; figs. 8–13, eight days old. Louisiana Purple, fig. 14, six days old. Madras Seedling No. 2, figs. 15 and 16, thirteen days old.

and widening of the leaves, so as not only to completely encircle the stem, but also to enclose the younger parts in a set of enveloping sheaths, and, later on, the gradual lengthening of successive joints, so that the growing plant is raised above the surface of the ground.

Immediately this occurs the stimulus of moisture and darkness being removed, the formation of roots falls into abeyance, but the root eyes can be detected in the root zone from the outside throughout the length of the plant. The leaf, at first purely protective and consisting of leaf base or leaf sheath, on emerging to the light, soon develops a small green tip, the leaf blade or lamina, and this part rapidly increases in relative size until it forms the bulk of the leaf. But this leaf development is much more rapid than that of the stem, so that, when the growing point of the stem at length reaches the surface the leaves have already reached a very respectable size (Pl. III). The largest seedling (fig. 4) has a leaf already a foot in length, whereas the stem is as yet only one-third of an inch long.

The cane seedling four or five months old, viewed from above ground, usually shows a tall central shoot surrounded at its base by a number of smaller shoots emerging from the soil near it. These are the developed buds of the lower leaf axils. As the first joints of the stem are very close together, and each has its lateral branch, these shoots, being pushed out of their original plane from lack of room, appear all together as an irregular circle round the main shoot, but careful dissection shows that they all arise from different axils on alternate sides of the plant (Pl. IV). The growth of successive buds, however, varies a good deal, and their size at this stage bears no sort of relation to the time at which they were formed at the apex of the stem. Some buds remain quite small during the life of the plant, whereas others grow so rapidly that they soon overtake or even exceed the main shoot in length.

The branches pass through exactly the same stages as the parent stem, only differing from it in that they have a better start and take less time to develop into leafy shoots. They are thin at the place of origin, bear closely packed leaves on the short congested joints, have a bud in the axil of each leaf, and, as the leaves increase in length and expand their blades, the stems increase in thickness, the successive joints become longer, and the shoots as a whole emerge from the ground. As in the main shoot, the leaves at first grow much faster than the stem and, for a long time, the actual growing points of the stems remain below the ground, the height of the plant being judged by the length of the expanded leaves. This is readily explained by the fact that the growth of each shoot is largely dependent on the feeding power of its own leaves and, until these are fairly large, no real progress can be made, hence their early protrusion and proportionately rapid early growth. The relative size of the main shoot and its branches and the number of the latter vary much in the same batch of seedlings, all stages being observable between one strong cane, with or without a few small shoots at its base, and a bunch of shoots resembling a tuft of grass, in which it is difficult to distinguish between the main stem and its branches. The reason for this is not clear, for seedlings thus differing in their early stages are often not distinguishable in their degree of branching later on.

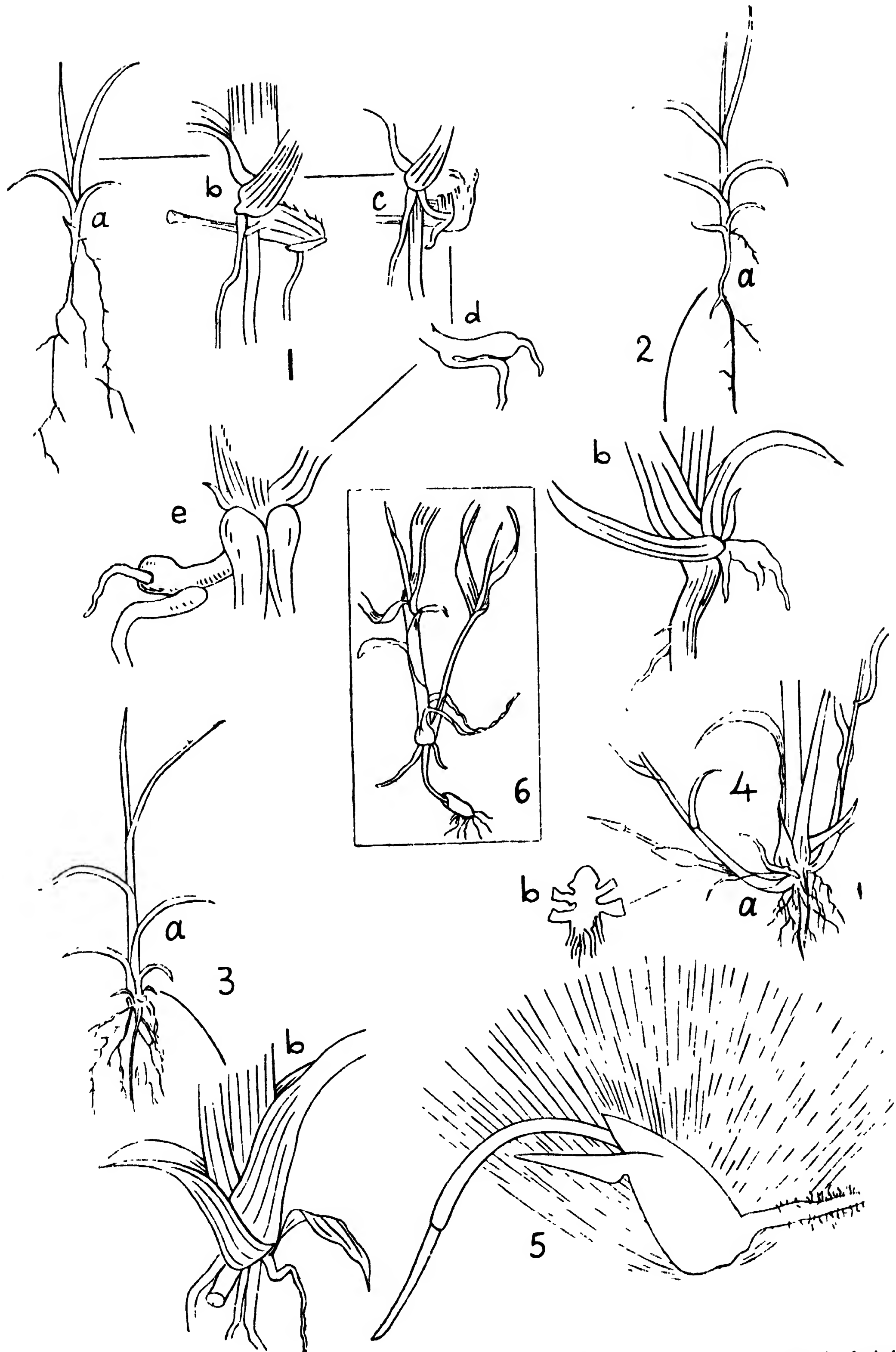


Plate III. Young cane seedlings. Figs. 1–4, Karun, from one inch to one foot in height. Fig. 5, germinating grass seedling. Fig. 6, young barley plant.

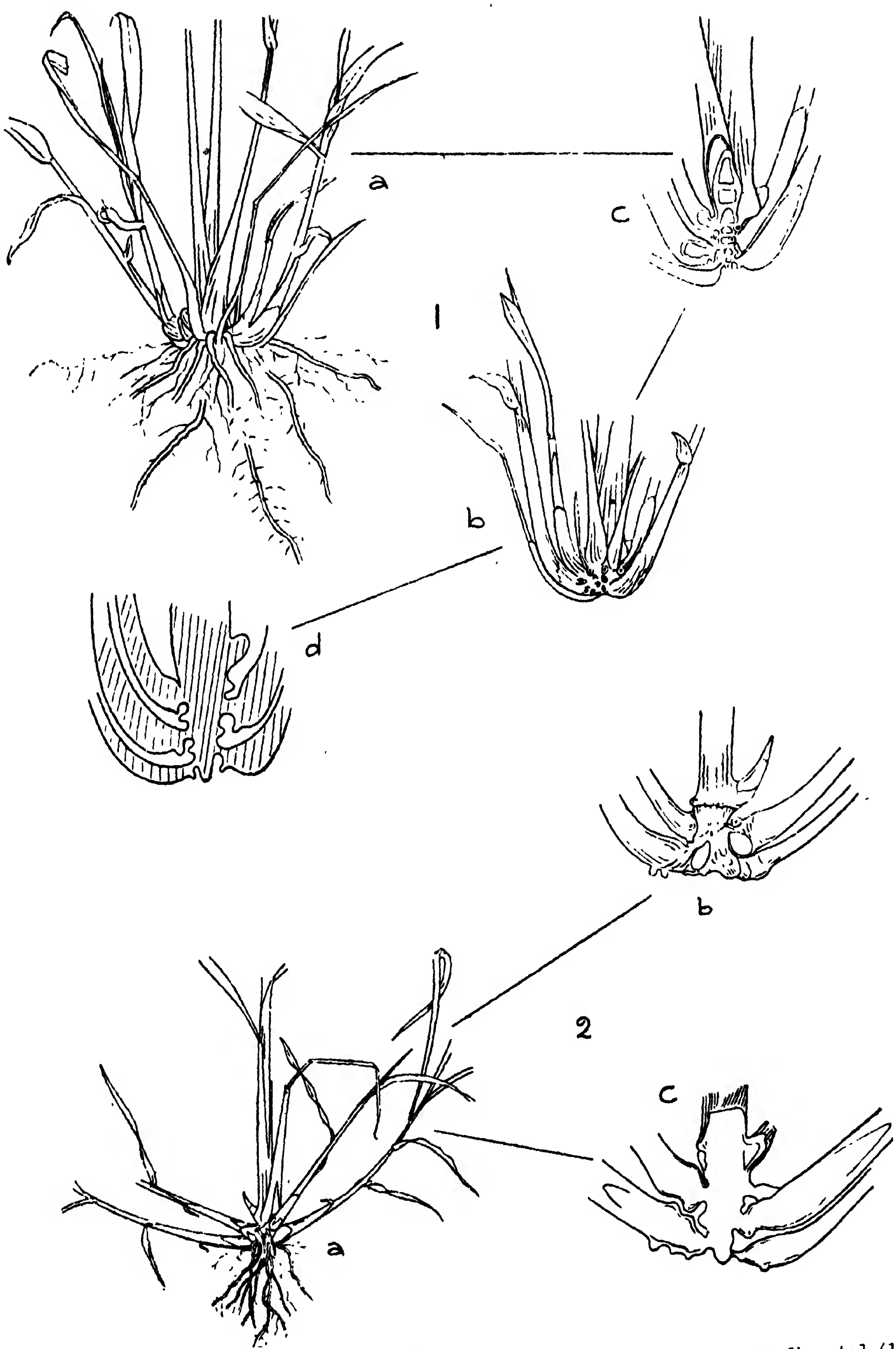


Plate IV. Cane seedlings about four months old. Fig. 1, Poovan seedling dissected (113 days old. Fig. 2, seedling of *Saccharum spontaneum* (133 days old).

At a somewhat later stage the lateral shoots, each as fully provided with buds as the parent stem, may also branch, giving rise to branches of the second degree, and this process may continue to several further degrees, this depending to a large extent on the parentage of the seedlings. Such shooting of the buds on lateral branches is not, however, usual until the plant has reached a further stage of development, unless, indeed, one of the branches receives an accidental injury low down, when its place is often taken by one of its uppermost buds.

The chief points to bear in mind concerning the branching of seedlings are that every joint has its leaf and, protected by it, a bud; that both joint and bud have the power of forming independent roots if the necessity should arise; and that any of these buds may remain quiescent or dormant throughout its life, or may shoot out at once or at a later stage in the growth of the plant as a whole. There is thus ample provision at hand for all the needs of the plant, whatever circumstances may arise However severe the treatment above ground, there is a reserve of branches ready to be developed below, and, if one of the branches is either accidentally or purposely cut off, its place is taken by the emergence of one of its buds; and, if such a cut branch is placed in the ground, it is capable of sending out its roots under the stimulus of moisture and darkness, protruding its buds and developing into an independent plant.

Advantage has been taken of these facts in the planting of the sugar cane in the field. Cultivated sugar cane is propagated from cut pieces of the stem and is always likely to be. Seedlings, although undoubtedly a much cheaper form of reproduction, do not inherit the good qualities of their parents uniformly, and many of them, even of the best parentage, are quite worthless from the sugar producing point of view. Although extremely easily reared in many cases, they require more individual attention than is justified under crop conditions, and they take longer to mature. While in South India canes grown from cuttings take, on the average, twelve months to mature, seedlings become full grown only when they are about eighteen months old. Besides this, there are many good kinds which do not produce seed at all, either because of infertility or the total absence of flowering. In vegetative reproduction the good qualities of the variety are rigidly handed down from generation to generation, although there appears to be a gradual diminution of vigor as the years pass.

The vegetative method of reproduction is rendered easy, as explained above, in that each joint is furnished with its bud and a number of root primordia, and both of these require little stimulus to grow out. The condition of the bud may be compared with that of the germ in the seed, in that it is placed in immediate connection with a mass of readily assimilable nutriment in the joint to which it belongs. It is, however, much more fully developed than the germ, and it takes little time, under suitable conditions of moisture and warmth, for it to produce a mass of roots and leaves. The development of this bud need not detain us here. It is practically identical with that of the shoots described above, being merely a branch of the plant of a higher order. A series of stages are shown in Plates V and VI.

In planting, the whole cane is sometimes laid in a furrow, lightly covered with earth and watered; in many places only the upper, immature parts of the cane are used, and these, called "tops," are placed slanting in the ground; but

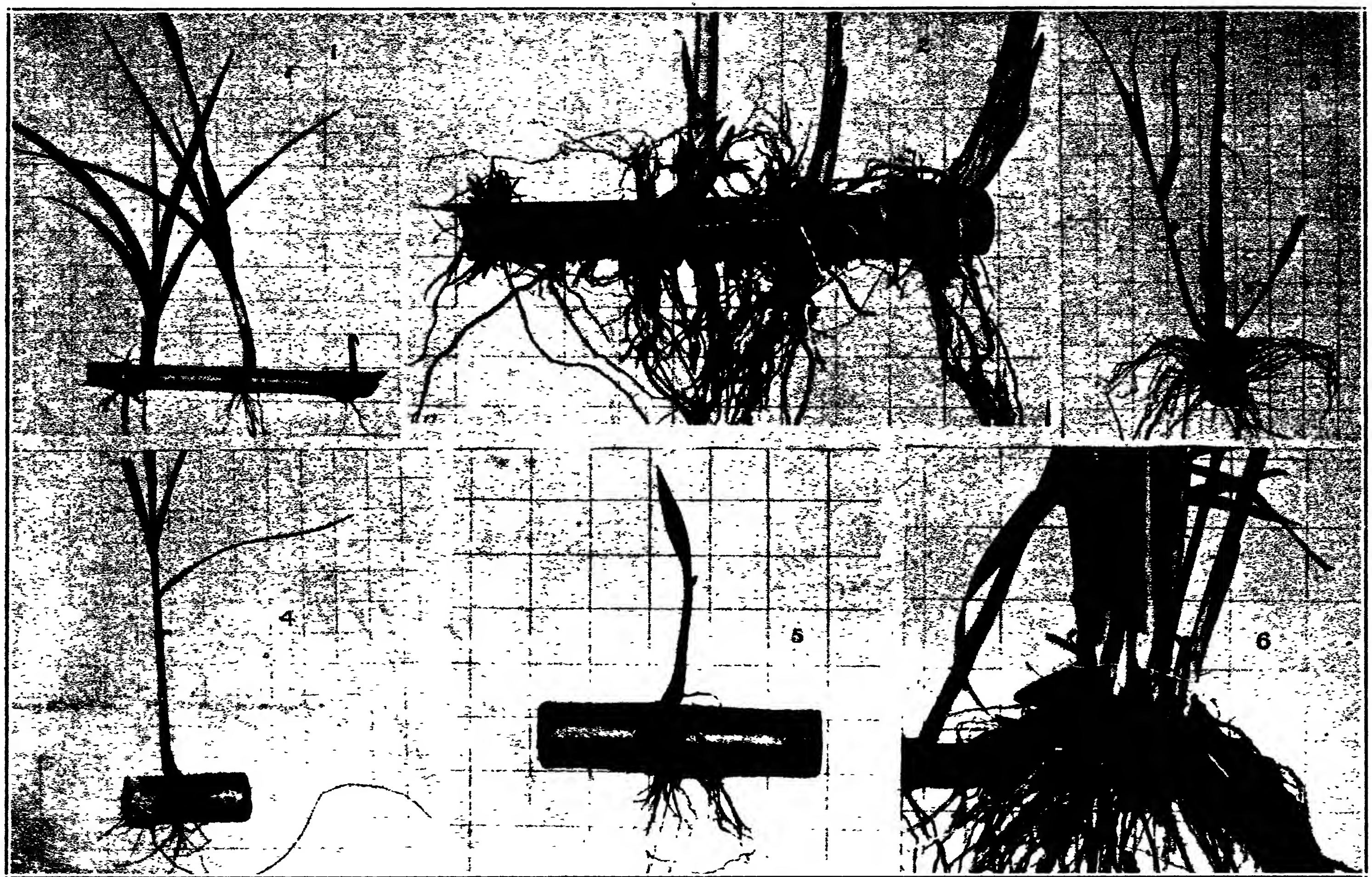


Plate V. Sprouting set plants. Fig 1. *Saccharum arundinaceum*, showing bud beneath the set curving upwards and forming a healthy shoot. Fig 2. Gillman, 25 days old. Fig. 3, Red Mauritius, 37 days old. Figs 4 and 5, Vellai, 37 days old. Fig. 6, Chin, 50 days old.

in India, as a rule, the whole cane is cut up into pieces called "sets," each of which has a definite number of joints with healthy living buds. Almost all canes germinate readily from sets, and, in India, they seem to produce healthier and stronger plants than the tops; but cases have been met with, as in *Scema* of the Godavari District, where sets are generally infertile and tops have to be used. The sets in South India usually contain three joints; germination takes place more rapidly than in North India, and if the field has not sprouted within a week or ten days it is customary to plant again. In North India the climate at the time of planting is very cold, and not infrequently a month elapses before the shoots appear above ground.

When, in a warm climate, the sets are placed horizontally in shallow trenches and watered, they at once send forth roots and the buds burst. Although, possibly, in ideal planting, it would be best to place the sets so that the bud plane lies parallel with the surface, this is not generally attended to nor essential, for the shoots are negatively geotropic and quickly find their way round the set to the surface of the ground.* The root eyes protrude and form a circlet of fibers round the set, those beneath growing much more strongly than those facing upwards, and these roots supply the stream of water which washes the nutriment stored in the joint to the developing bud. But very soon the lower joints of the new shoot form their own roots—thicker, whiter, and longer. When this occurs the shoot forms a new, independent plant, and the decayed joint from which it has arisen is left behind, much as the cast-off seed-coats in a germinated seedling. Connection with the plants developed from the other buds in the same set is thus entirely severed. Lateral branching takes place very early in the young plant, and these branches also produce their own roots, and, in a couple of months, the set plant has attained to the size and form of the six months seedling and is growing much more rapidly.

The canes of different ages in the same clump are sometimes very different. This has been already noted in the remarks on early and late canes. But this difference is much greater in seedlings than in canes grown from cuttings. It is true that all the canes seem to be similar in some cases, but in others it is not unusual to note thin, yellow, sprawling canes developed first, these succeeded by reddish tinged slanting canes, while the latest formed are thick and dark purple; and all sorts of such color variations may be detected, as well as variations in thickness and erectness. We do not as yet know whether this variability is handed on to the next generation, when the seedling is grown vegetatively, or whether only one of the forms of cane noted is characteristic of the future crop cane, but experiments are being conducted to determine this point, which is of considerable moment for the proper selection of seedlings.

* Since writing the above our attention has been drawn to the following. Kulkarni, in Dharwar, has made a series of experiments in planting sets, each with one bud only, and the set placed so that this bud is upward. He allowed only the mother shoot to grow and its branches were carefully removed. He claims that, by this means, sprouting takes place one week earlier, all the canes ripen together and a larger number are obtained per acre. (Kulkarni, M. L. Experiments in planting sugar cane sets with single eye-buds, etc. Agr. Jnl., Ind., Special Science Congress Number, 1918.)

(2) Periods of Growth.

The great bulk of the Order Gramineae consists of grasses, and it will be of interest briefly to consider their mode of branching, in order to see in what respects the sugar cane resembles them — for the sugar cane has often been described as a gigantic grass. There are two well marked phases of development in grasses: the first, in which the plant remains low and adds shoot to shoot until a dense bush is formed, in which the shoots are often inextricably intertwined and point in all directions; and, second, in which the ends of certain of these branches become erect, rapidly increase in length and proceed to form the spikes of flowers and ears of grain. In the first stage the energy of the plant is devoted to multiplying its number of shoots, chiefly by the branching of the underground portion; in the second, branching ceases and the energy is diverted to pushing the branches high into the air and the formation of flowers where they can be readily fertilized, and the seed where it can be scattered abroad.

In the sugar cane this division into periods of growth is to a certain extent hidden, in that, both in seedlings and set plants, each shoot, as soon as it is formed, pushes into the air and grows steadily upwards to form the aerial stem or cane. Flowering is a matter of secondary importance, and has largely fallen into desuetude from long propagation by the vegetative method. This is especially so in North India, where flowering is rare, but in the Peninsula, as in most tropical countries, flowering takes place regularly towards the close of the growing season, and the fields then present a mass of feathery plumes over the whole area. It may be noted, in passing, that the time of flowering does not coincide with that of reaping the crop, as these two periods are induced by very different climatic conditions Flowering occurs at Coimbatore during the period of greatest rainfall, in October and November, and indeed seems to be greatly influenced in its profusion by the amount of rain falling during the year; while the cane is harvested when the juice is richest, and this occurs in February and March, after the cold season, when the air becomes hot and dry.

The formation of new shoots at the base of the cane plant proceeds during the whole of the growing period, but there is no doubt that it is much more active at the commencement of growth, for the rapid formation of canes is not really taken up until the plant is six or seven months old. And this separation of the branching and lengthening periods of the plant is in certain cases emphasized by local conditions of growth. In South India the sets are planted at the commencement of the hot, dry weather, when the harvest is reaped, sugar cane being everywhere an irrigated crop. In the Godavari District, the young plants, after growing for a few months, receive a severe check, in that the irrigation channels are closed every year in May for cleaning, and for some six weeks irrigation is in abeyance, and the plants depend on such scanty showers as fall at this time. During this period the branching of the underground parts goes on steadily, although little is added to the height of the plants. In fact the plants often appear to grow shorter, in that they are attacked by shoot-borer and many of the shoots are destroyed. But the ryot views the matter with equanimity, because he knows that this pest merely causes the lateral branches to be

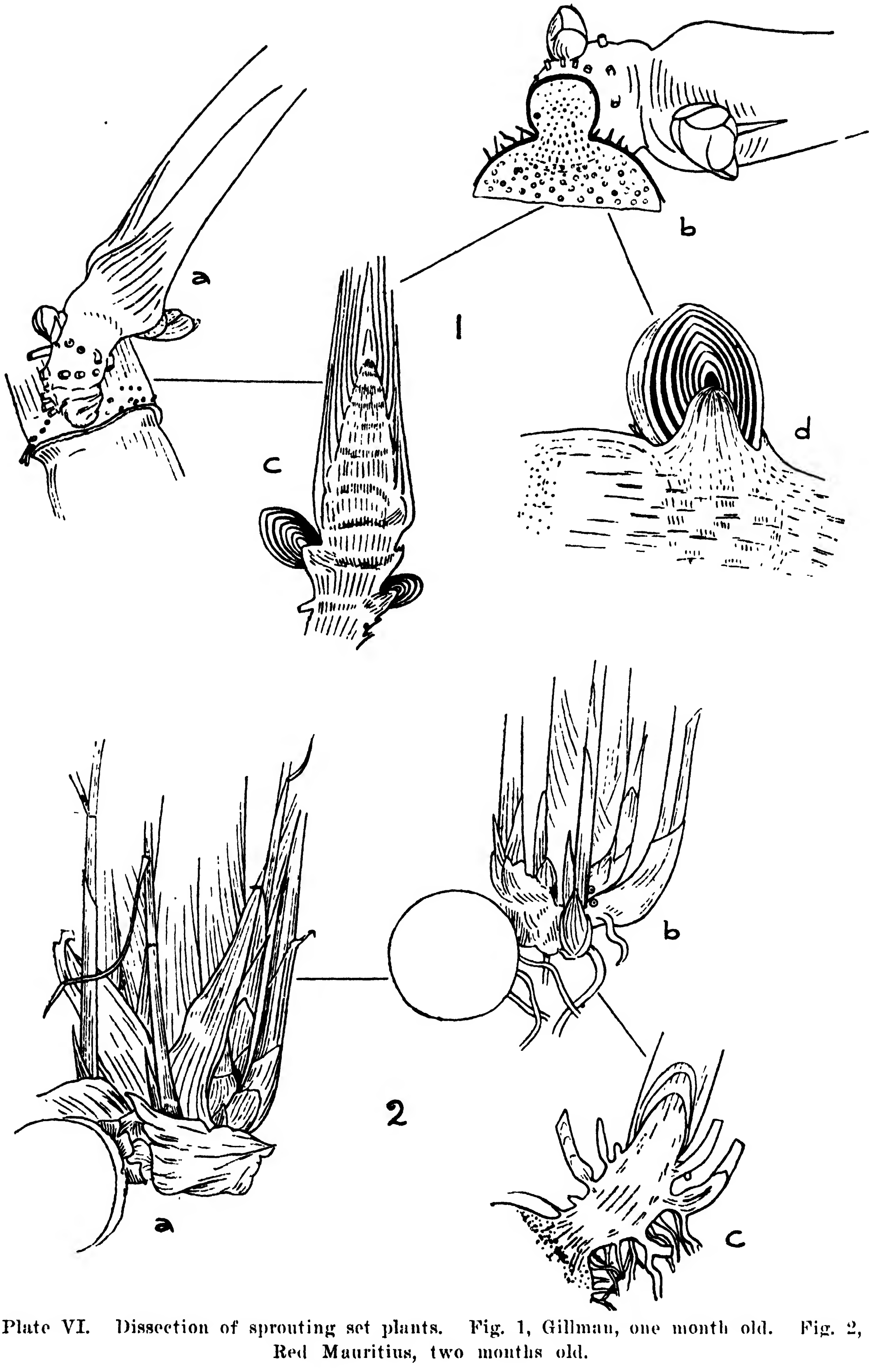


Plate VI. Dissection of sprouting set plants. Fig. 1, Gillman, one month old. Fig. 2, Red Mauritius, two months old.

developed in larger numbers, and he asserts that he gets a better stand of canes when there is an attack of moth borer. It is probably of no great disadvantage for the shoots to be checked when there is no water to continue their growth; but cases are also met with where whole fields are destroyed by the pest, or ugly gaps are seen in the plantations. The branching period is lengthened and made more pronounced in this case, which in some respects is analagous to winter-sown wheat in Europe.

A similar lengthening of the branching period is to be noted as the result of certain diseases of the cane. In the neighborhood of Coimbatore, where many of the wells contain brackish water, sometimes the plants, especially ratoons, never reach the cane-forming period, but continue throughout the season to develop new shoots with narrow leaves, which do not grow in length, but branch again, until, at crop time, nothing is seen but a number of low, dense, grassy bushes. A case was met with by the author on new, rough land, near the emergence of the Amravati River from the hills, where, in a couple of acres fourteen months old, only a few cases were observable, and the field closely resembled one of *Guinea grass*. It is needless to point out the similarity of this growth to that induced by *Sereh* in Java and certain diseased clumps observed years ago in Barbados, where all the buds and roots of the short canes shoot out, till a dense mass of grassy leaves is produced in place of a few tall, healthy canes.

Another feature in the branching of grasses may be noted here. It is usual to divide them, according to their mode of growth, into tufted grasses and sod-formers. In the latter, underground branching assumes an intense form, each bud piercing the base of its enveloping leaf sheath and again branching itself, until, with the masses of roots formed at the bases of the joints, the soil is permeated so thoroughly that it can be cut into coherent slabs, as in lawns and permanent pastures. The individual plants are closely interlocked and it becomes very difficult to dissect them out without injury. The main feature in these grasses is the great development of underground runners or stolons, the ends of which emerge and bear tufts of leaves for the purpose of nutrition, while their place is taken by buds near the upward bend, and the underground part is thus formed of a mass of sympodia. Flowering takes place at a certain season, but this does not interfere with the underground branching. In the tufted grasses, on the other hand, after a limited period of underground branching, a number of erect shoots are formed, which in due course proceed to the formation of flowers and grain. The buds in this case do not pierce the bases of the enclosing leaf sheaths, but grow up inside them, emerging where the sheath joins the lamina, only splitting the leaf sheath by their increase in thickness. The individual plants are easily separable, do not interlock, and each forms a more or less distinct tuft.

It is at once obvious that the sugar cane belongs to the latter class, as do the usual cultivated cereals. This also applies to the wild Saccharums, *Munja*, *Narenga*, *arundinaceum* and *spontaneum*, grown on the Cane-breeding Station. The two former are typical tufted grasses; no cane is formed and the flowering shoots are ephemeral structures, drying up after the seed is ripened. In *Saccharum arundinaceum* and *Saccharum spontaneum*, solid canes are formed. *Saccharum spontaneum*, although undoubtedly a tufted form, produces long un-

derground shoots which emerge at intervals and thus spread the plant over a considerable area. It is difficult in growing this species, either from seed or from sets, to confine it to its bed, and the neighboring paths are soon invaded. We may thus imagine an approach to the sod- former here. The nearest approach to sod-formation in *Saccharum spontaneum* which we have observed is on the banks of the Irrawaddy, where sandbanks are protected from being washed away by an interlacing mass of roots and runners, which forms a solid cap a foot in thickness. The formation of underground runners is occasionally met with in cultivated canes. It is commonest in the Saretha group, the most primitive class of indigenous Indian canes, and, apparently, the nearest in descent to the wild *Saccharum spontaneum*. In other classes runners usually are formed only where space is needed for the free development of a large number of cane stems. Thus we meet with them most frequently in the Mungo and Pansahi groups, which are characterized by much branching. In these cases long, thin joints are intercalated between the normal short, thick ones of commencing shoots, and in the dissections these are always noted.

(3) The Branching of the Cane Above Ground and Abnormal Bud Formation.

Branching of the cane plant below ground is a well marked feature in all varieties. Above ground, in the light and in the absence of the stimulus of moisture, the buds usually remain inactive during the period of maximum growth. But the shooting of aerial buds is by no means uncommon, and is of some disadvantage from the crop point of view. It has been noted that some varieties, such, for instance, as B. 208, shoot more readily than others; but there are a number of circumstances which render all canes more or less liable to this defect. Any injury to a growing cane will tend to cause the buds below the injured place to shoot out because of the damming up of the current of water and nutrition. This is often seen where stem-borer is at work. The joints immediately above the attack are shorter and thinner than the average, and large shoots are often observed coming from the nodes below the borer hole. Canes which have lodged or fallen will frequently develop a mass of shoots all along the prostrate part; over-ripe canes and such as have flowered usually form a mass of shoots in the upper part if allowed to continue growing; lastly, the local climate has a very distinct influence in the matter. Thus, when the same canes are grown at Pusa and at Coimbatore, they behave very differently as regards shooting. At Coimbatore, which is in a semi-arid region, shooting of the canes is very rare; while at Pusa, with its abundant supply of subsoil water, approaching the surface in the rains, a great mass of green is sometimes seen all the way up the stem, even in erect canes, long before the reaping season.

This shooting of the buds is generally correlated with a more or less active protrusion of the root eyes. In places where there is a marked difference in the humidity and temperature at different periods of the cane's growth, this difference is often permanently marked on the different joints of the cane stem. Thus, at Rajshahi, in North Bengal, it is easy at crop time to determine what joints had been formed during the hot, dry summer months, and at what stages

the rains attained their maximum and ceased to flood the ground. The rooting and shooting of the canes in damp climates is often avoided by trashing, or pulling off the adherent but dying leaves, and it would be worth while considering the desirability of trashing canes in North India during the rains, in places where these defects are most marked.

Besides the normal branching of the cane, due to the protrusion of the ordinary buds on the joints, cases of abnormality are not infrequently met with, caused by irregularity in the bud development. Here and there canes have been met with where the joints have been altogether devoid of buds, and Kaghze has been marked in the Coimbatore collection as especially liable to this deformity. Here obviously no branching can take place. In others, double or triple buds have been met with in place of the single bud, and in the usual position. Where double buds occur they are not infrequently the prelude to a dichotomous splitting of the cane into two equal halves, each of them proceeding to grow normally. On passing down the stem, such double buds are seen to be preceded by buds of abnormal width, accompanied by a flattening of the stem. Such cases have been very clearly described by Jeswiet,[1] and need not be further dealt with here. Among the cases of triple buds, one was noted as being extremely regular in its development; and it was preserved because of its interesting nature. After four years of reproduction the same abnormality can be seen, showing that it is a hereditable character of the seedling when propagated by cuttings.

But the most striking and frequent case of abnormal bud formation is when they are irregularly produced in different parts of the stem without any regard to the usual position. They are often met with in the root zone, for here there is, more or less permanently, meristematic tissue, but they may also appear at almost any part of the joint. They may arise direct from the outer layers of the stem, but more usually they are preceded by the formation of an irregular mass of callus, over which the buds are distributed unevenly, varying from mere pin points of tissue to fully formed buds with scaly leaves. Curious monstrous forms are thus produced. They would appear to be commoner on seedlings of certain parentage, although they have been found sporadically in almost all the plots, thus conveying the suggestion that the formation of cane plants from seed is no longer governed by the strict rules applicable to seed-bearing plants. In 1917–18 the Khelia plot of seedlings was thus marked out as containing numerous examples of this deformity. The cases thus far mentioned do not seem to have their origin in any injury to the cane tissues, but, in other cases, the callus results from the hole of a stem-borer, the breaking of a cane, or the curious "cuts" above the bud in the groove, to which attention was drawn in the Journal of Heredity of February, 1916. These cuts have been found in many of our seedlings and cane varieties on the farm, and appear not to be the result of any insect or other attack, but on differences in tension of the superficial layers of the stem. They have been found also in seedlings of *Saccharum spontaneum* in some quantity. A large number of other abnormalities have been noted in the seedlings and varieties grown on the station, and the study of these would undoubtedly prove of interest from the morphological point of view.

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[1] Jeswiet, J. Beschrijving der soorten van het suikerriet. Erste bijlage. Morphologie van het suikerriet. Archief v. d. Suikerind. in Ned. Ind., Maart, 1916.

Sugar Prices

96° Centrifugals for the Period

March 15, to June 15, 1922.

Date	Per Pound	Per Ton	Remarks
March 16, 1922..	3.98 ¢	$79.60	New Cubas.
" 17	4.045	80.90	Porto Ricos 3.98, new Cubas 4.11.
" 23	3.98	79.60	New Cubas.
" 24	3.86	77.20	New Cubas.
April 3	3.89	77.80	New Cubas 3.98, Porto Ricos 3.80.
" 4	3.98	79.60	Porto Ricos.
" 5	4.11	82.20	New Cubas.
" 13	4.04	80.80	New Cubas.
" 17	3.86	77.20	Porto Ricos.
" 20	3.805	76.10	Porto Ricos 3.86 and 3.75.
" 21	3.75	75.00	Porto Ricos.
" 24	3.86	77.20	Porto Ricos.
" 25	3.92	78.40	Porto Ricos 3.86, new Cubas 3.98.
" 26	3.98	79.60	New Cubas.
" 27	4.0433	80.866	Philippines 3.98, new Cubas 4.11 and 4.04.
" 29	3.92	78.40	Porto Ricos.
May 1	3.995	79.90	New Cubas 3.98, new Cubas 4.01.
" 4	3.98	79.60	New Cubas.
" 5	3.87	77.40	Philippines 3.86, Porto Ricos 3.88.
" 6	3.98	79.60	New Cubas.
" 9	3.9825	79.65	Porto Ricos 3.86 and 3.92, new Cubas 4.04 and 4.11.
" 10	3 9667	79.334	New Cubas 4.04, Porto Ricos 3.98 and 3.88.
" 11	3.98	79.60	New Cubas 4.04, Porto Ricos 3.98, Philippines 3.92.
" 12	4.04	80.80	New Cubas.
" 22	4.00	80.00	Philippines.
" 24	4.1608	83.216	Philippines 4.125, new Cubas 4.17, Porto Ricos 4.1875.
" 25	4.17	83.40	New Cubas.
" 26	4.20875	84.175	New Cubas 4.23, Philippines 4.1875.
" 31	4.265	85.30	New Cubas 4.23 and 4.30.
June 2	4.30	86.00	New Cubas. Summer Saturday market holidays begin tomorrow.
" 9	4.6175	92.35	Philippines 4.625, new Cubas 4.61.
" 14	4.6175	92.35	Cubas.
" 15	4.50	90.00	Porto Ricos.

THE HAWAIIAN PLANTERS' RECORD

Volume XXVI. OCTOBER, 1922 Number 4

A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

Intensifying Agriculture

Important factors which govern sugar production are climate, land area, labor, water, and nitrogen.

In cost accounting we usually give the monetary cost per ton of sugar or per ton of cane. We express yields ordinarily in terms of tons of cane or tons of sugar per acre.

It is generally conceded that on unirrigated plantations yields are limited by adverse temperature or lack of sufficient rainfall. On irrigated lands, enjoying for the most part more favorable temperature, yields are held in check by a lack of sufficient irrigation water. Probably no irrigated plantation has, throughout the year, all the irrigation water that it would like. The labor supply also affects yields. Even under what might be a normal adequate supply, there are seasons of the year when extra labor could be used to great advantage and with telling effect upon yields of cane and sugar. Labor, without question, is a limiting factor in production, just as water is.

It is suggested, therefore, that we study yields with respect to what is required to produce these yields in the terms of labor and water and other essentials.

It has been shown in various reports during the past few years that it takes in round numbers about one million gallons of water on the average irrigated plantation to produce a ton of sugar. This figure includes rainfall as well as irrigation water and embraces a large part of the seepage losses in ditches.

If 40,000 laborers, working 250 days a year, produce annually 500,000 tons of sugar, each ton of sugar has called for 20 man-days of labor. This, as a rough average figure, is subject to considerable variation, say 15 to 25, or perhaps even wider limits.

Purchased supplies are not a limiting factor in the same sense that labor and water are, for we are drawing upon sources which are not restricted and we are concerned, not with adjusting our operations to conform with a given inelastic supply, but with purchasing such an amount of material as can be used

to economical advantage in connection with limited supplies of labor and water and land.

For instance, if we are using 150 pounds of nitrogen per acre and are getting six tons of sugar, each ton of sugar is costing 25 pounds of nitrogen. In an effort to increase our yield we are at liberty, economically, to draw upon the world's supply of nitrogen at this rate for every ton of sugar we are able to increase our yields.

Such a course is not open to us when we consider either labor or water. If the six tons of sugar have cost us six million gallons of water, any proposed increase in the amount of water to be supplied per acre must very likely be accompanied by the development of more water, or by a reduction in the number of acres we are to hold under irrigation.

Any proposed change in our agricultural methods looking toward better results on an irrigated plantation must, therefore, be considered in its relation to:

(1) yield per acre
(2) yield per man-day of labor
(3) yield per million gallons of water.

If a field method is devised that affects the first of these favorably, it is sound only if it does not affect one of the other items adversely. We have nothing to gain by a method which produces more sugar per acre at a cost of more labor or more water per ton of sugar.

A method which calls for more labor per acre is admissible whenever it reduces the labor and water requirements per ton of sugar. The prime objective of a plantation is not to cultivate a given number of acres. A reduction in area as a means of obtaining better yields per *acre*, per *man-day of labor*, per *million gallons of irrigation water* is worth considering. Before an extensive sacrifice in area for the purposes named can be undertaken safely, a plantation must first determine, through experiments on a commercial scale, the high yield possibilities of its fields, and what these yields cost in labor and water *per ton of sugar*. The possible benefits that accrue from fallowing are to be given due consideration as a part of this plan.

Where adverse climatic conditions set a low limit on sugar yields, improvements in agricultural methods are to be directed along the lines of low cost of production *per acre*.

This is sometimes called "extensive" agriculture to distinguish it from intensive agriculture that seeks high acreage yields. But if we adopt the term we must not overlook the fact that, under the so-called "extensive" methods, we are merely intensifying our efforts in another direction, that of producing the highest practicable amount of sugar per man-day of labor, or per dollar of expense.

According to this viewpoint, all of our agriculture is, or should be, intensified. Taking a given set of plantation conditions — area, water, labor, nitrogen, and temperature — one may determine, through a careful diagnosis of the case, the weak link in the chain of raw materials we are to make into sugar cane. Then we intensify in the direction that takes full advantage of that factor which tends to limit production. Here we are concerned not so much with yield

per acre as with yield *per unit of limiting factor,* such as sugar per man-day of labor, or sugar per million gallons of water. If it takes 75 man-days of labor per acre to produce three tons of sugar, we become seriously concerned in reducing the labor per ton of sugar. If climatic conditions form a barrier that limits consideration of higher yields than three to four tons of sugar per acre, we intensify upon making every man-day of work count for all it can in sugar production. The elimination of unessential operations, the substitution of animal or motor power, the use of implements, or automatic irrigation, all tend to reduce the labor requirement, and hence invite consideration. Cane varieties that close in quickly and ratoon freely reduce weeding to a minimum and offer interesting possibilities.

The actual value in sugar of each field operation can be determined, or estimated carefully. Just as the plantation operating under favorable climatic conditions is concerned with commercial trials to determine the possibilities of high yields per acre, so a plantation operating under adverse conditions discovers the importance of systematic work which covers the various points already mentioned, and formulates field methods which are pertinent to its especial needs.

Sugar: 15.36 Tons per Acre on 288 Acres.

The Ewa Plantation Company this year has harvested five fields, covering an area of 288.81 acres, which have produced sugar at the average rate of 15.36 tons per acre.

These yields, obtained under plantation field conditions, set a new mark in sugar production. The variety was H 109. The treatment of these fields embraced four fundamental requirements for best results, namely: (a) heavy fertilization with nitrogenous salts, (b) adequate irrigation throughout the growing period of the cane, (c) the last application of fertilizer occurred practically one year before harvesting, and (d) the irrigation was stopped at 60 to 90 days before harvesting.

Of these fundamentals the first two work toward high yields of cane; the second two operate in ripening this cane so as to reduce the number of tons of cane per ton of sugar. The following data show the record of four individual fields with respect of three of these points:

Field	Nitrogen per Acre	Period Between Last Fertilization and Beginning of Harvest	Period Between Last Irrigation and Beginning of Harvest
16-A	271 lbs.	365 days	89 days
16-B	260 "	358 "	74 "
16-C	256 "	341 "	60 "
1-E	251 "	363 "	66 "

These figures are supplied by George F. Renton, Jr., Manager, Ewa Plantation Company, who furnishes other details bearing upon the results. The fifth field was harvested after the details on the other four had been supplied, and the information on that field is that "83.17 acres of plant cane yielded 107.53 tons of cane per acre, requiring but 6.95 tons of cane to make a ton of sugar, so that there were produced 15.35 tons of sugar per acre."

An interesting feature to be noted is that the Ewa Plantation Company has adopted the plan of expressing yields not only as tons-of-sugar-per-acre, but also as tons-of-sugar-per-acre-per-month. The way in which this operates toward making full use of growing time cannot be fully appreciated until the expression is put into use and yields are discussed on this basis of comparison. Mr. Renton's letter regarding the first four fields reads:

"Replying now to your letter of July 11, asking for information concerning high yields of certain fields at this place, I beg to submit the following data:

"The yields obtained were as follows:

Field 16-A	24.79 acres	15.25 tons sugar per acre
" 16-B	49.55 "	15.58 " " " "
" 16-C	72.50 "	15.14 " " " "
" 1-E	58.80 "	15.51 " " " "

FIELD 16-A (24.79 ACRES), 1922 CROP, PLANT CANE:

"(1) Before planting Field 16-A was harvested April 12th to 16th, 1920.

"(2) The field was planted July 10th to 14th, 1920. (A heavy rain of 1.85 inches occurred on July 12th.) The seed was unselected body seed from 12-months old cane (Fields 20-B and 9-A). It was planted butt to butt and required 61 bags per acre. It did not germinate well and 24 bags per acre of replant were required to make a solid stand. Strikebreakers (Hawaiian women and Boy Scouts) did the planting.

"(3) Irrigation rounds averaged 10.7 days from August 1st to November 1st. Heavy winter rains made irrigation unnecessary until March. From then until the following November the rounds averaged 16.42 days apart. From December to May, the rainfall was distributed as follows:

December, 1921	5.00 inches
January, 1922	2.23 "
February, 1922	.12 "
March, 1922	1.62 "
April, 1922	.10 "
May, 1922	.43 "

" 'Third season' irrigation consisted of one round completed on March 16th, or 89 days before the field was harvested.

"The laboratory record gives the following juice analysis:

Tons can per ton sugar	7.23
Percent sucrose	14.86
Brix	20.78
Polarization	18.18
Purity	87.49

"The cane was well matured and ripe.

"(4) The field was not fertilized until December 7th, the delay being due to the labor situation following the strike. Eleven hundred and twenty-nine pounds per acre of 'F' fertilizer were applied, giving 113 pounds of nitrogen per acre, 34 pounds of K_2O, and 34 pounds of P_2O_5. Two doses of 508 pounds per acre of nitrate of soda were applied in the irrigation water finishing on March 23rd and June 13th. This made the field receive a total of 271 pounds of nitrogen.

"(5) There was a good growth of weeds to contend with, the charges being $3.00 per acre for this item.

"(6) Harvesting commenced on June 15th and was completed on June 21st, 1922, making the cane about 23 months old, 0.663 being the sugar per acre per month, 15.25 tons sugar per acre per crop, 110.28 tons cane per acre per crop.

FIELD 16-B (49.55 ACRES), 1922 CROP, PLANT CANE:

"(1) Before planting, Field 16-B was harvested April 6th to 14th, 1920.

"(2) The field was planted July 14th to July 25th in damp soil, following a 1.85-inch rain on July 12th. The seed was unselected body seed from 12-months old cane (Fields 20-B and 9A). It was planted butt to butt, requiring 80 bags per acre. Germination was not good, 10 bags per acre of replant being needed to make a solid stand. Strikebreakers (Hawaiian women and Boy Scouts) did the planting.

"(3) Irrigation rounds averaged 13.55 days from August 1st to December 1st. Heavy winter rains made irrigation unnecessary until March. From then until the following November, the rounds averaged 20.1 days apart. From December to May, the rainfall was distributed as follows:

December, 1921	5.00	inches
January, 1922	2.23	"
February, 1922	.12	"
March, 1922	1.62	"
April, 1922	.10	"
May, 1922	.43	"

" 'Third season' irrigation consisted of one round completed on March 16th, or 74 days before the field was harvested.

"The following laboratory record gives the juice analysis:

Tons cane per ton sugar	7.75
Percent sucrose	14.16
Brix	19.52
Polarization	16.98
Purity	86.99

"The cane could have been ripened further.

"(4) The field was not fertilized until December, the delay being due to the labor situation following the strike. One thousand and forty-seven pounds per acre of 'F' fertilizer were applied, giving 105 pounds of nitrogen per acre and 31 pounds of K_2O and 31 pounds of P_2O_5. Two doses of 500 pounds per acre of nitrate of soda were applied in the irrigation water, finishing on March 30th and June 14th, 1921.

"(5) There was a good growth of weeds to contend with, the charges being $3.00 per acre for this item.

"(6) Harvesting commenced on June 7th and finished on June 19th, 1922, making the cane approximately 23 months old.

Tons sugar per acre per month	.677
Tons sugar per acre per crop	15.58
Tons cane per acre per crop	121.08

FIELD 16-C (72.50 ACRES), 1922 CROP, PLANT CANE:

"(1) Before planting Field 16-C was harvested April 14th to 22nd, 1920.

"(2) The field was planted July 25th to August 3rd. The seed was unselected body seed from 12-months old cane (Fields 20-B and 9A). It was planted butt to butt and required 69 bags per acre. Replanting too $3\frac{1}{2}$ bags per acre. Planting was done by strikebreakers, who were Hawaiian women and Boy Scouts.

"(3) Irrigation rounds averaged 13.55 days from August 19th to December 22nd, 1920. Heavy winter rains made irrigation unnecessary until March. From then until the following November, the rounds averaged 20.1 days apart. From December to May, the rainfall was distributed as follows:

December, 1921	5.00	inches
January, 1922	2.23	"
February, 1922	.12	"
March, 1922	1.62	"
April, 1922	.10	"
May, 1922	.43	"

'Third season' irrigation was completed on March 11th. The field had two rounds and 'Dryspotting.' Irrigation was suspended 60 days before harvesting.

"(4) The field was not fertilized until December 7th, the delay being due to the labor situation following the strike. One thousand and twenty-four pounds per acre of "F" fertilizer were applied, giving 113 pounds of nitrogen per acre, 31 pounds of P_2O_5 and 30 pounds K_2O. Two doses of nitrate of soda, 496 pounds per acre each, were applied in the irrigaton water, finishing on March 21st and June 19th. The field thus received a total of 256 pounds of nitrogen.

"The laboratory record gives the following juice analysis:

Tons cane per ton sugar	7.86
Percent sucrose	13.88
Brix	19.13
Polarization	16.69
Purity	87.25

"The cane could have been ripened further except a 12-acre portion of the field on shallow coral soil.

"(5) There was a vigorous weed growth, especially in the coral area; the charges were $3.00 per acre for this item.

"(6) The harvesting commenced on May 26th and finished June 8th, 1922, making the cane about 23 months old.

Tons sugar per acre per month	.673
Tons sugar per acre per crop	15.14
Tons cane per acre per crop	119.00

FIELD 1-E (58.80 ACRES), 1922 CROP, PLANT CANE:

"(1) Before planting Field 1-E was harvested May 20th to May 27th, 1920.

"(2) The field was planted August 8th to 17th, 1920. The seed was unselected body seed from 12-months old cane in Field 9-B. It was planted butt to butt and required 71 bags per acre. Germination was poor, as it took 14 bags per acre to replant it. Field was planted by Boy Scouts.

"(3) Irrigation rounds averaged 13.5 days from September 1 to November 9. Winter rains made irrigation unnecessary from December 22nd to February 17th. From then until the end of October, the rounds averaged 23 days apart. From December to May, the rainfall was distributed as follows:

December, 1921	5.00	inches
January, 1922	2.23	"
February, 1922	.12	"
March, 1922	1.62	"
April, 1922	.10	"
May, 1922	.43	"

'Third season' irrigation was completed on April 15th, 1922, consisting of nearly one complete round, or 66 days prior to harvesting.

"The laboratory record gives the following juice analysis:

Tons cane per tons sugar	7.05
Percent sucrose	15.12
Brix	21.12
Polarization	18.37
Purity	86.98

"(4) The field was not fertilized until December 7th, the delay being due to the labor situation following the strike. One thousand and six pounds per acre of "F" fertilizer were applied December 6th, 1920, equivalent to 101 pounds of nitrogen, 30 pounds of P_2O_5 and 30 pounds of K_2O. Two doses of nitrate of soda, of 500 pounds each, were applied in the irrigation water, being finished on March 25th and June 23rd. The field thus received a total of 251 pounds of nitrogen per acre.

"(5) There was weed growth, the charges for hoeing being $3.53 per acre.

"(6) Harvesting commenced on June 21st and finished June 7th, 1922, the cane being not quite 23 months old.

Tons sugar per acre per month	.67
Tons sugar per acre per crop	15.51
Tons cane per acre per crop	109.34

Potash in the Hilo District.

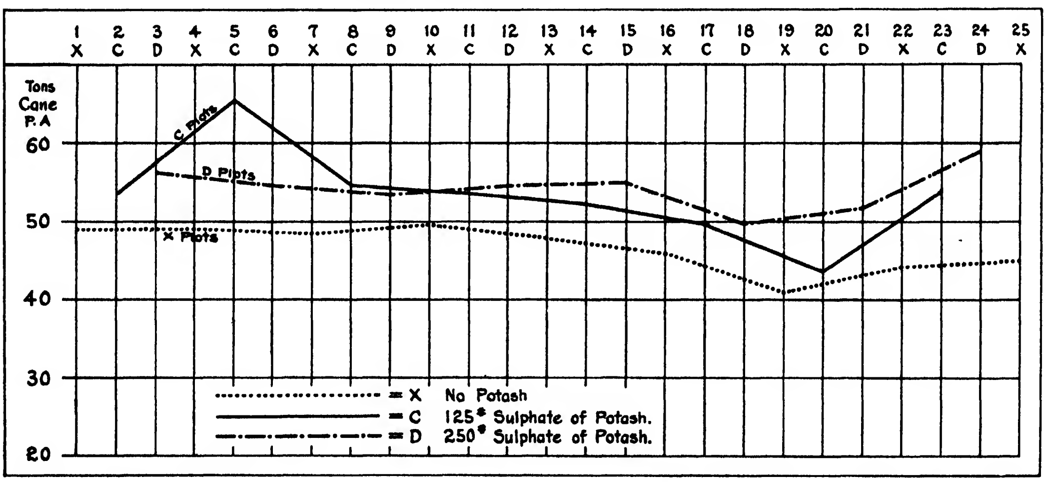
By J. A. Verret.

Pepeekeo Experiment No. 6, 1922 Crop.
Onomea Experiment No. 11, 1922 Crop.

We have recently harvested two experiments in the Hilo district, from both of which we obtained distinct gains from the use of potash.

Experiment No. 6 at Pepeekeo compared 125 and 250 pounds per acre of sulphate of potash with no potash. The cane was Yellow Caledonia, planted August 6, 1920, and harvested May 1, 1922. All plots received equal amounts of nitrogen from 750 pounds of sulphate of ammonia per acre. This was applied in three equal doses, in October and November, 1920, and March, 1921. The potash was applied in late August, 1920.

AMOUNT OF POTASH
Pepeekeo Sugar Co. Exp. 6, 1922 Crop
Field 2A.



The results obtained at harvest are tabulated as follows:

Treatment	Tons Cane per Acre
No potash	46.8
125 lbs. sulphate of potash	51.7
250 lbs. sulphate of potash	54.4

Results of a similar nature were obtained in several experiments at Onomea.

A ton of cane, as it goes to the mill, removes from 2 to 3 pounds of potash (K_2O) from the soil. A part of this is returned to the fields in the mud press cake and mill ashes.

We see from this that unless we wish to further deplete the already low potash in the soils of the Hilo district, we should add at least 120 pounds of K_2O per acre per crop. If all mud press cake and mill ashes are returned the above amount should take care of a 40-ton crop without too great a strain on the soil.

In fields averaging yields much above this it would be advisable to use larger amounts of potash.

In experiment No. 11 at Onomea we compared equal amounts of K_2O from sulphate of potash, muriate of potash, and molasses ash.

The cane was Yellow Caledonia, planted May 1, 1920, and harvested June, 1922 The potash was applied May 14, 1920. All subsequent fertilizations were uniform to all plots. On July 13, 1920, 300 pounds of nitrate of soda per acre were applied. On September 21, 1920, and March 22, 1921, applications of ammonium sulphate were made at the rate of 300 pounds per acre.

The results obtained at harvest are given below:

Treatment	Pounds K_2O	Tons Cane per Acre
Sulphate of potash	75	40.3
No potash	...	33.1
Muriate of potash	75	39.8
No potash	...	34.3
Molasses ash	75	38.5
No potash	...	35.4

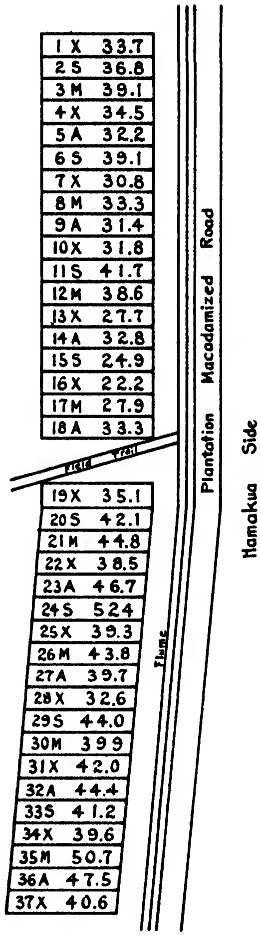
The above results are slightly in favor of sulphate of potash, and although final conclusions cannot be drawn on the results of one experiment, at about equal cost per unit of K_2O, the sulphate should be preferred. The sulphate should be preferred for other reasons also. On irrigated plantations large amounts of chlorides are being added to the soils in the pump waters. We should not increase these amounts if we can help it.

In the rainy districts the lime content of the soils has a tendency to be low. When using muriate of potash the chlorine in the muriate would tend to combine with lime, forming calcium chloride, which is rather soluble in water. This would cause a rather rapid loss of lime. Sulphate of potash, on the other hand, would cause the formation of calcium sulphate, which is only very slowly soluble in water.

Forms Of Potash
Onomea Sugar Co. Exp. 11, 1922 Crop
Field 95.

Summary of Results

Plots	Treatment	Tons Cane Per Acre
S	75# K2O from Sulphate of Potash.	40.3
X	No Potash	33.1
M	75# K2O from Muriate of Potash.	39.8
X	No Potash.	34.3
A	75# K2O from Molasses Ash.	38.5
X	No Potash.	35.4



Details of Experiments.

ONOMEA EXPERIMENT 11,—1922 CROP.

Potash: (1) *Value of:*
(2) *Kind to apply:*

Object:

To determine the value of applying potash, and to compare the following forms:

Sulphate of Potash (46.96% K_2O).
Muriate of Potash (54.24% K_2O).
Molasses Ash (33.92% K_2O).

Location:

Onomea Sugar Co., field 95 (along Hilo side of macadam road, running through Paukaa Section.

Crop:

Yellow Caledonia, plant cane, (planted May 1, 1920).

Layout:

Number of plots = 37.

Size of plots = 1/10 acre, consisting of 6 lines, each line 5.5 feet wide and 132.0 feet long.

Plan:

Fertilization.

Plots	Number of Plots	May 15, 1920 Kinds of Potash	Pounds Potash	Total K_2O
X	13	None	.....	...
S	8	Sulphate of potash	159.7	75 lbs.
M	8	Muriate of potash	138.3	75 "
A	8	Molasses ash	221.1	75 "

Fertilization:

Uniform according to the following schedule:

Pounds of Nitrate of Soda per Acre.

	July 15, 1920	Sept. 21, 1920	March 15, 1921	Total Nitrogen
All plots ..	300	400	300	155

Pepeekeo Sugar Co. Experiment No. 6. (1922 Crop).

Object:

To determine the amount of potash to apply.

Crop:

Yellow Caledonia, planted August 6, 1920; harvested June, 1922.

Location:

Pepeekeo Sugar Co., field 2A.

Layout:

Twenty-five plots, each 1/10 acre, consisting of 6 lines, 6.17 feet wide, 117.7 feet long.

Plan:

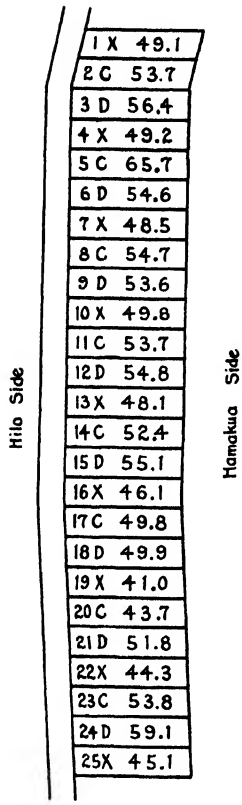
Fertilization — Pounds per Acre.

Plots	Number of Plots	Aug., 1920 Sulph. Potash	Oct., 1920 Sulph. Ammo.	Nov., 1920 Sulph. Ammo.	March, 1921 Sulph. Ammo.
X	9	...	250 lbs.	250 lbs.	250 lbs.
C	8	125 lbs.	250 "	250 "	250 "
D	8	250 "	250 "	250 "	250 "

AMOUNT OF POTASH

Pepeekeo Sugar Co. Exp. 6, 1922 Crop

Field 2 A.



Summary of Results

Plot	No. of Plots	Treatment	Yields Per Acre		
			Cane	Q. R.	Sugar
X	9	No Potash.	46.8	7.88	5.94
C	8	125# Sulphate of Potash	51.7	7.82	6.61
D	8	250# Sulphate of Potash.	54.4	8.28	6.57

Notwithstanding these points in favor of the sulphate over the chloride, the fact remains that in practice the chloride has found a wide field of usefulness in the fertilizer markets of the world and is perhaps more extensively employed than sulphate.

Field trials generally, drawing from mainland and European results, show for most crops little or no difference between sulphate and chloride of potash. A few crops, however, show much better results with sulphate, the chloride apparently having a toxic effect.

As to whether sugar cane is to be classed among the plants that make better response to sulphates than chlorides is a matter to be established by further tests.

Molasses ash usually contains chlorides to sulphates in the proportion of about two to one and small quantities of carbonate of potash are also present.

Flume System of Irrigating Sugar Cane.

By H. W. Baldwin.

PREPARING: This system may be used on any field regardless of contour, as it is adapted to both hilly and moderately level land.

After the field has been well harrowed, the flume lines which have been previously worked out on the contour map, are staked out in the field. These flume lines are laid out in such a way that the furrows can be run from either side in "herring bone style," with rows between 150 feet and 200 feet, more or less, in length. These rows should have a fall of from one to three feet per 100 feet preferably, but may have more or less as required. They may be straight or curved according to the contour of the field.

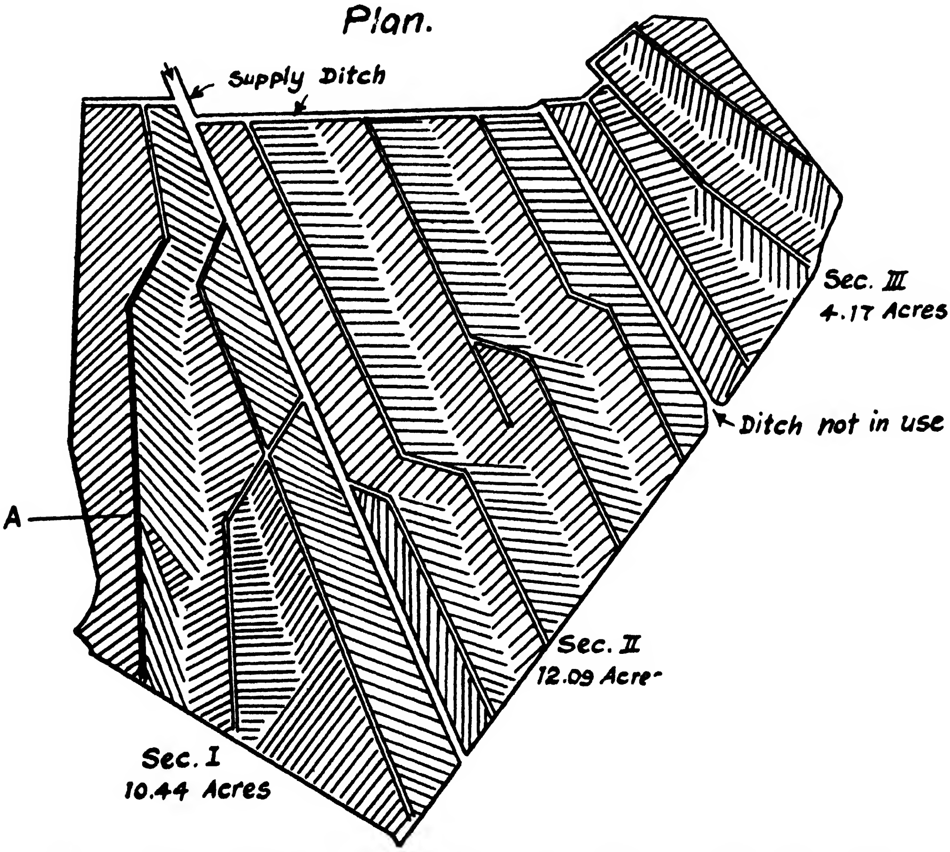


Fig. 1. Map of 27-acre field planted to flume system in September, 1921.

FURROWING: We are trying two methods of spacing and furrows. In one section the furrows are spaced 1¾ feet apart and in the other 2 feet apart, as shown in the sectional view, Fig. 2.

The cane is planted in two adjoining furrows, then a furrow is left for water and the next two furrows are planted and another furrow is left for water. etc. Thus the water furrows are spaced 5¼ feet apart in Section 1, and 6 feet

apart in Section 2, with two rows of cane in between. This results in 16,620 linear feet and 14,520 linear feet of cane rows respectively per acre, or 98% more cane per acre in one case and 73% in the other, than by the regular system.

The direction of the rows is laid out by the surveyors, a line of cane tops marking the lines at intervals of about 50 feet.

The furrows are made with a furrowing sled having 8" x 8" runners set on edge. On the 27-acre plot which we are now raising by this system, a small two-runner furrowing sled was used. (Fig. 3.) This was drawn by a pair of horses, the driver riding on the sled.

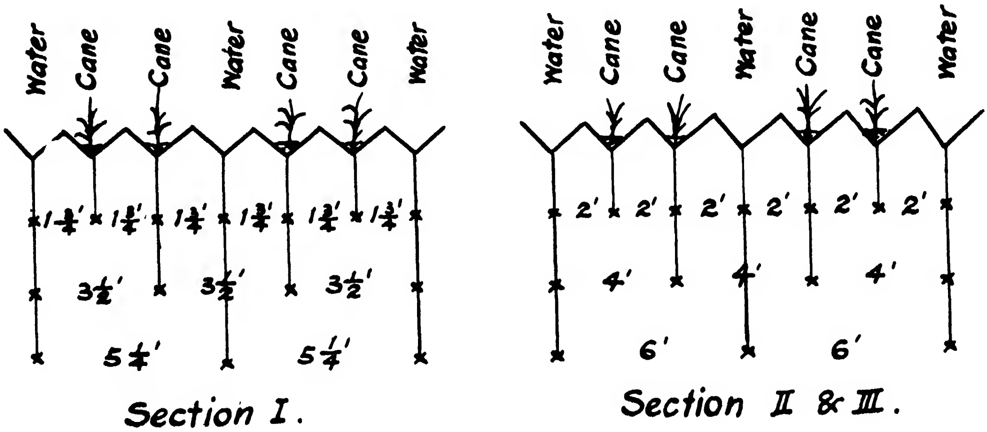


Fig. 2. Showing spacing of furrows.

COVERING: After the seed was dropped a small furrow (Fig. 4) was made with the hoe between the adjoining cane rows, covering the seed at the same time. This small furrow was used for the first few irrigations or until the roots were established, after which the water was supplied in the regular water furrows.

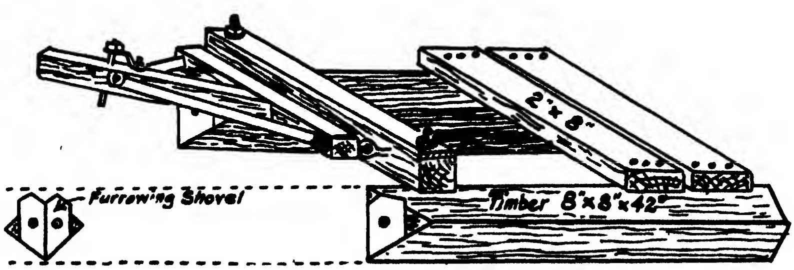


Fig. 3. Furrowing sled.

COMBINED FURROWING, PLANTING AND COVERING SLED: This year we expect to use a two-row furrowing sled equipped with a seed dropping apparatus which will enable us to furrow, plant and cover all in one operation.

FLUMES: The flumes are laid in the field after the furrowing is completed, as otherwise they would interfere with the movements of the furrowing sled.

The flumes are made of one-inch redwood, surfaced on the inside. It is economy to use surfaced lumber as it reduces friction and gives greater capacity. The economical size of flume is one in which the width is about double the depth.

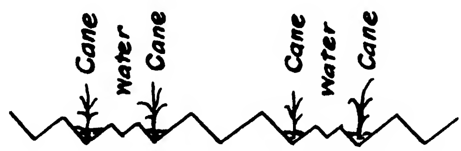


Fig. 4. Showing furrows used for the first irrigation.

The maximum size of flume to start with is 6 inches deep by 10 inches wide. The flumes should be placed in the ground slightly in order that the tops will be about level with the ground surface, so that the horses can cross readily when cultivating.

Two-inch holes are bored in the sides of the flume opposite the water furrows These holes are fitted with galvanized iron gates, Fig. 6. We have been placing these gates on the inside, sliding upward, but they are often bent by the horses' feet in crossing the flume, so hereafter we plan to place them on the outside to slide horizontally, Fig. 7.

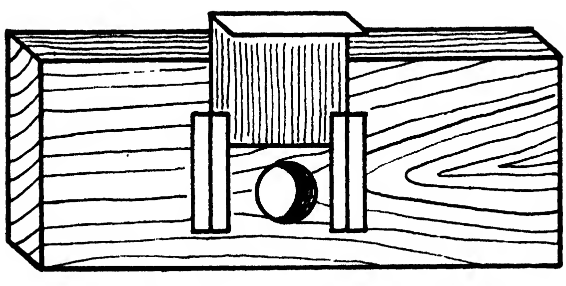


Fig. 6. Galvanized iron gate attached to scrap lumber.

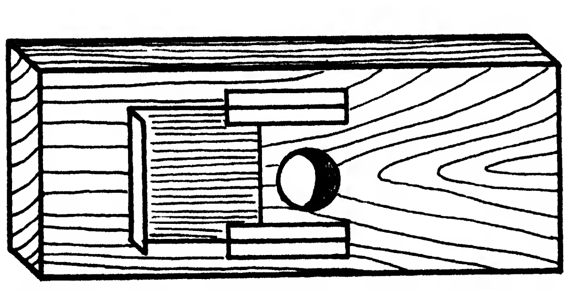


Fig. 7. Galvanized iron gate sliding horizontally, to be adopted.

DISCHARGE PER OUTLET: With the holes wide open and a depth of three inches of water in the flume, each hole will discharge about .044 cubic feet per second. After the first two or three irrigations the water flows much faster in the row than at first and the discharge per hole can be gradually lessened. By the fifth or sixth round the desirable flow is about .0146 sec. feet.

A 6″ x 10″ flume will carry approximately 2.5 sec. feet, depending on the grade. This is sufficient for about 45 rows for the first water, or 170 rows for fifth or sixth water, or for 700 linear feet of flume, as there are about six holes per 25 feet of flume.

Each 25 foot section of flume will discharge through its six outlets a total of about .0876 sec. feet after the sixth round, and each succeeding section will carry .0876 sec. feet of water less than the preceding one, and the flumes should be designed accordingly, so that they will gradually taper down and be full at all points. If the flumes are not full it is necessary to place small sticks, about an inch square and a little longer than the width of the flume, diagonally across the floor of the flume to back the water up by the outlet so that a sufficient flow will issue.

At the end of the 700 foot section of flume a level ditch should be brought in to feed the next 700 foot section, etc. This level ditch will cross some of the cane rows and the portion of the rows below the ditch should be irrigated from the ditch by means of small pieces of scrap 1″ x 6″ lumber about eight inches long inserted in the ditch bank in such a way that water will flow through holes bored in the board. These holes should have gates attached similar to the ones in the flumes. Lath tubes can be used for the same purpose, but should have galvanized iron gates to control the flow. (Fig. 8.) Short level ditches can often be used in this way to save flumes where the contour of the land is favorable.

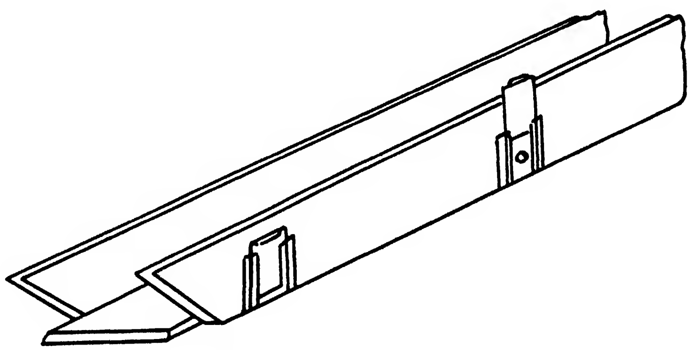


Fig. 5. Showing construction of flumes.

IRRIGATION: The first two or three irrigations are applied in the small furrow in the narrow space between the cane rows. (Fig. 4.) The water reaches half way down the row in a comparatively short time, but has now become so diminished that it progresses very slowly. It was found to be economy to shut the water off from the row about this time and not attempt to water the last half of the row until the following day, by which time the ground has settled in the first half of the row and become less pervious than it was the day before. When the stream now reaches the middle of the row again, which it does very quickly, it is much larger than it was the previous day and the last half of the row can be watered in much less time than would have been required the day before.

After the first 45 rows or so have been irrigated the small gates are closed and the next 45 rows are irrigated, etc.

With each succeeding irrigation the water will run faster and the size of the stream in each row will be gradually diminished until there will be sufficient water to supply all the holes in the 700-foot section of flume at one time. The gates should now be adjusted so that the water will reach the ends of the rows at about the same time. After this the gates will not have to be changed.

The first irrigation requires from six to seven inches of water per acre, but subsequent irrigations take less and less until in the fifth or sixth round it is found that with each row receiving .0146 sec. feet only one acre inch per acre will be applied per hour, so that it is necessary to allow the water to flow for several hours in order to give a sufficient application.

We are irrigating every week, as we believe that a light application of two or three inches per week will give better results than four or six inches every two weeks.

The fact that water running in a long row for several hours does not result in a waste of water seems rather unbelievable to some; in fact, it seems inconsistent with the writer's former experiments given in the report of the "Committee on Irrigation" at the annual Planters' meeting of 1920. But it is really not as inconsistent as it seems, for in the former case we were dealing with large flows of water running in level furrows which have been undisturbed by cultivation and have been baked in the sun for from fifteen to twenty days after each irrigation.

We are now dealing with entirely different conditions. Here we have furrows with a fall of from two to three feet per 100 feet. The ground is pulverized by frequent cultivation which forms a mulch and conserves moisture. With a weekly application of water followed by cultivation the optimum moisture content is practically maintained and the ground does not become baked. The constant stirring of the soil by the cultivator breaks up the soil into small particles which are carried by the water into the pores below, closing them and effectively

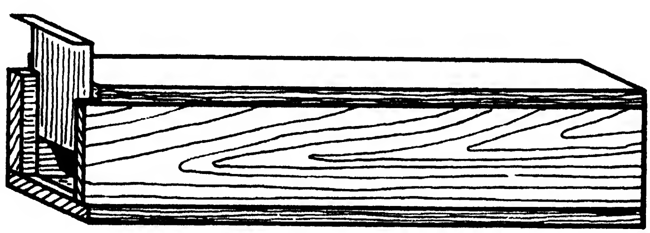
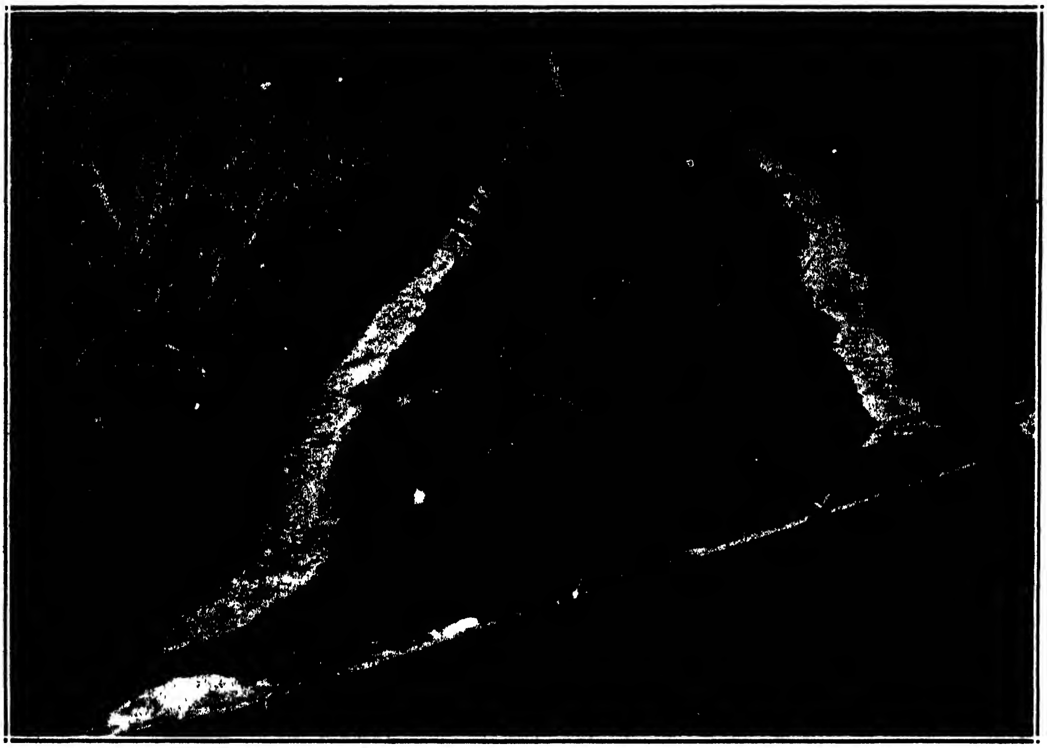


Fig. 8. Lath tube with galvanized iron gate.

preventing excessive water losses by deep percolation. The water flowing down the rows as a thin sheet penetrates downward as well as laterally, practically by capillary action. The longer the surface is kept saturated the longer this capillary action will continue. Water spreads farther by capillary action in a fine-textured, compact soil than in a loose, coarse soil, but requires a longer time, whereas, in the latter case it spreads faster but not so far. It is believed that a much greater lateral penetration is obtained by allowing a small stream to run for a long time than would result with a large stream running for a short time.

The action of the fine soil particles in retarding deep percolation losses is somewhat analogous to the action of slow sand filters such as those of the Hawaiian Commercial and Sugar Company, in which water is filtered through beds

of sand. After a few days the interstices of the sand surface become so stopped by silt that even with several feet head the water penetrates so slowly that several inches of sand have to be removed from the surface of the sand beds at frequent intervals.



A field of young cane, showing the double row method of planting under the flume system of irrigation.

ACRES IRRIGATED PER MAN PER DAY: On the 27 acre field the flumes are all of one size, namely, 4″ x 8″. No level ditches were used to feed the flumes except at the beginning, consequently the flume carries only enough water to supply about half the holes at a time. When these are finished the gates have to be closed so that the lower part of the flume will be supplied. At the next irrigation the gates have to be opened again. This involves considerable labor and prevents the nice adjustment possible with the improved system which will do away with the opening and closing of the gates after they are well adjusted. One man now irrigates the 27 acres in three days.

With the improved system properly installed as outlined above, and the gates well adjusted, the irrigator will simply turn the proper amount of water into the flumes and allow it to run for several hours. The water will then flow into all of the rows automatically and the attendant will have only to patrol the flumes to see that none of the outlets are obstructed and to inspect the ends of the rows to be sure that the water has reached the ends and had ample time to

spread laterally before the water is turned off. Thus it should be possible for one man to irrigate a whole field in a day if there is a sufficient volume of water available.

First ratoons of D 1135, grown under the flume system of irrigation.

CULTIVATION: After the roots are established the water is applied in the regular water furrows between the double rows of cane instead of in the furrow between the single rows of cane. The first irrigation in the water furrow will require a great deal of water but the subsequent irrigations will require less. After the second or third round in the water furrows, cultivation is started. About two days after the irrigation a one-horse Planet Jr. cultivator is used, equipped with side hoes and irrigation shovel in the rear. This is run in the water furrow, the horse stepping over the flumes while the cultivator is lifted over. The cultivator destroys the weeds on two-thirds of the surface area and forms a soil mulch which conserves moisture, and the furrow is left ready for the next irrigation. The only hand-weeding required is on the narrow strip between the cane rows. Only two or three hand-weedings are required, as the cane shades in quickly on this narrow strip so that the weeds do not grow.

The cultivator is used for five or six months or until the cane becomes too large to permit the cultivator to pass between the rows. As the cane grows the side hoes are removed and a larger shovel with side wings used which throws more dirt onto the cane.

YIELD: From the small plot of D 1135 cane raised by this system last year we obtained 92.7 tons of cane per acre which yielded 10.35 tons of sugar per acre. Single rows of cane raised by the same system gave 78.3 tons of cane and 8.32 tons of sugar per acre.

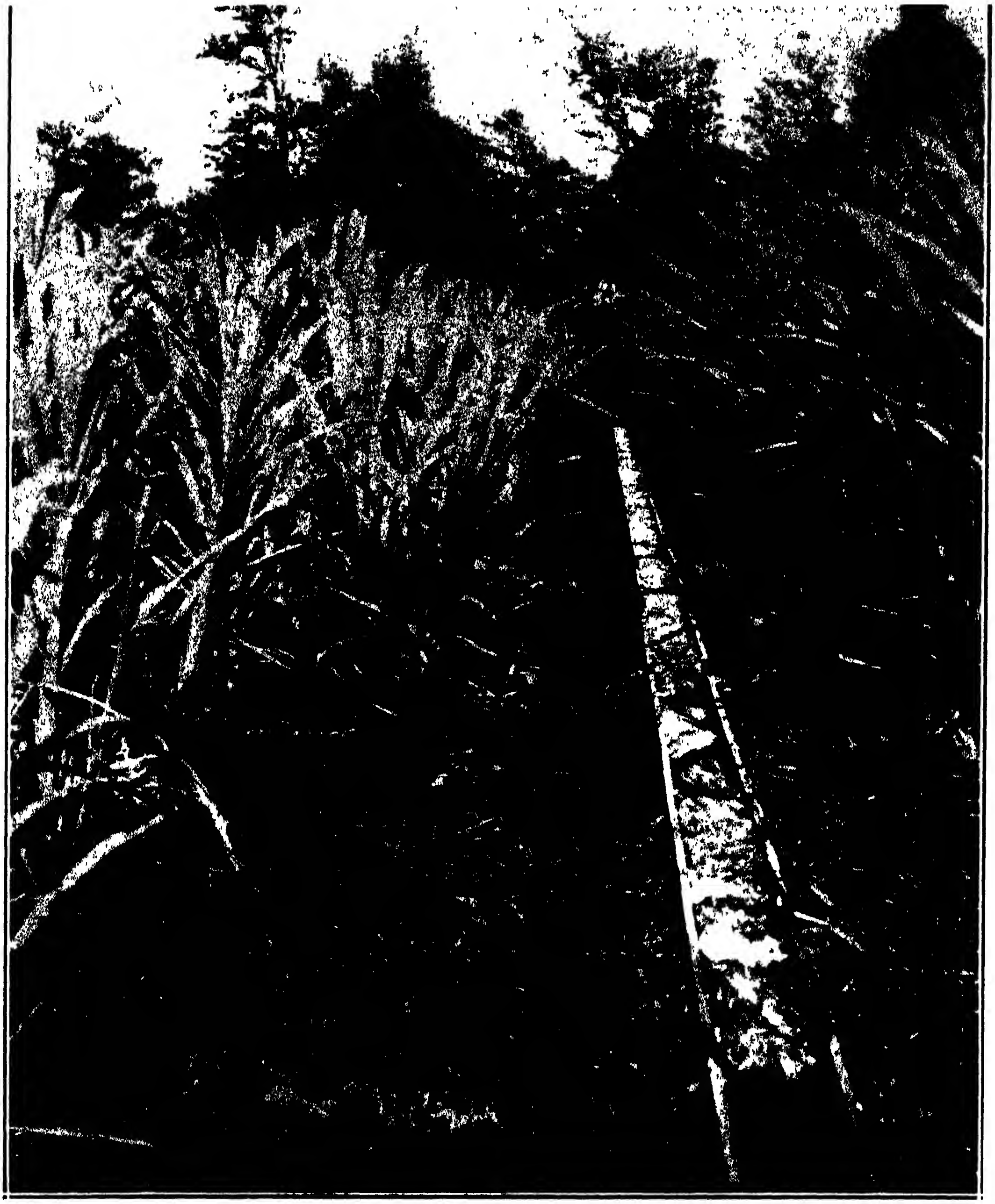
WATER APPLIED: The water applied to this crop was as follows:

Round No.	Inches per Acre.
1	6.20
2	6.12
3	4.60
4	4.31
5	4.06
6	2.18
7	1.62
8	2.24
9	1.06
10	1.78
11	2.13
12	1.66
13	1.46
14	1.85
15	1.78
16	1.58
17	2.18
18	2.13
19	1.42
20	1.53
21	1.14
22	1.53
23	1.64
24	1.59
25	1.53
26	2.25
27	1.85
28	1.38
Total irrigation water	64.80
Rainfall	27.20
TOTAL WATER APPLIED	92.00 ACRE INCHES

Thus 1,002 pounds of water were required to produce one pound of sugar.

In this experiment the aim was to see how much sugar could be raised with a minimum amount of water. On the 27 acre plot this year we are giving heavier applications of water with the expectation of increasing the yield.

DUTY OF WATER IN HAWAII: The following table, taken from the U. S. Department of Agriculture Bulletin No. 90, by Walter Maxwell, gives comparative figures on the "Duty of Water in the Hawaiian Islands." To this table have been added the figures given above as well as like data reported in the April, 1922, *Planters' Record*, showing results obtained at Waipio and elsewhere.



The small streams of water are issuing from the right-hand side of the flume. One of them can be seen in the immediate foreground of this picture.

This field of H 109 cane was also handled by the new irrigation system.

DUTY OF WATER IN HAWAIIAN ISLANDS.

	Water Applied per Acre per Crop		Yield of Sugar per Acre	Water Required to Produce One Pound of Sugar
	Depth	Quantity		
According to Schuyler & Allardt:	*Inches*	*Gallons*	*Pounds*	*Pounds*
Spreckelsville (1)	262.00	7,114,348	11,100	5,345
Spreckelsville (2)	216.00	5,865,264	11,100	4,407
Hamakuapoko	230.20	6,250,850	11,300	4,613
At the Experiment Station:				
First crop (1897–98)	94.51	2,567,682	24,755	865
Second crop (1898–99)	103.01	2,797,133	27,133	859
April (1922) Record (1921) ..	187	....	19,700	2,140
Hamakuapoko:				
Field 8 (1920–21)	216.96	5,892,518	10,100	4,860
Field 3 (1921–22)	92.00	2,490,000	20,700	1,002
Average given in Planters' Record of April, 1922, for Oahu, Maui and Kauai..				3,898

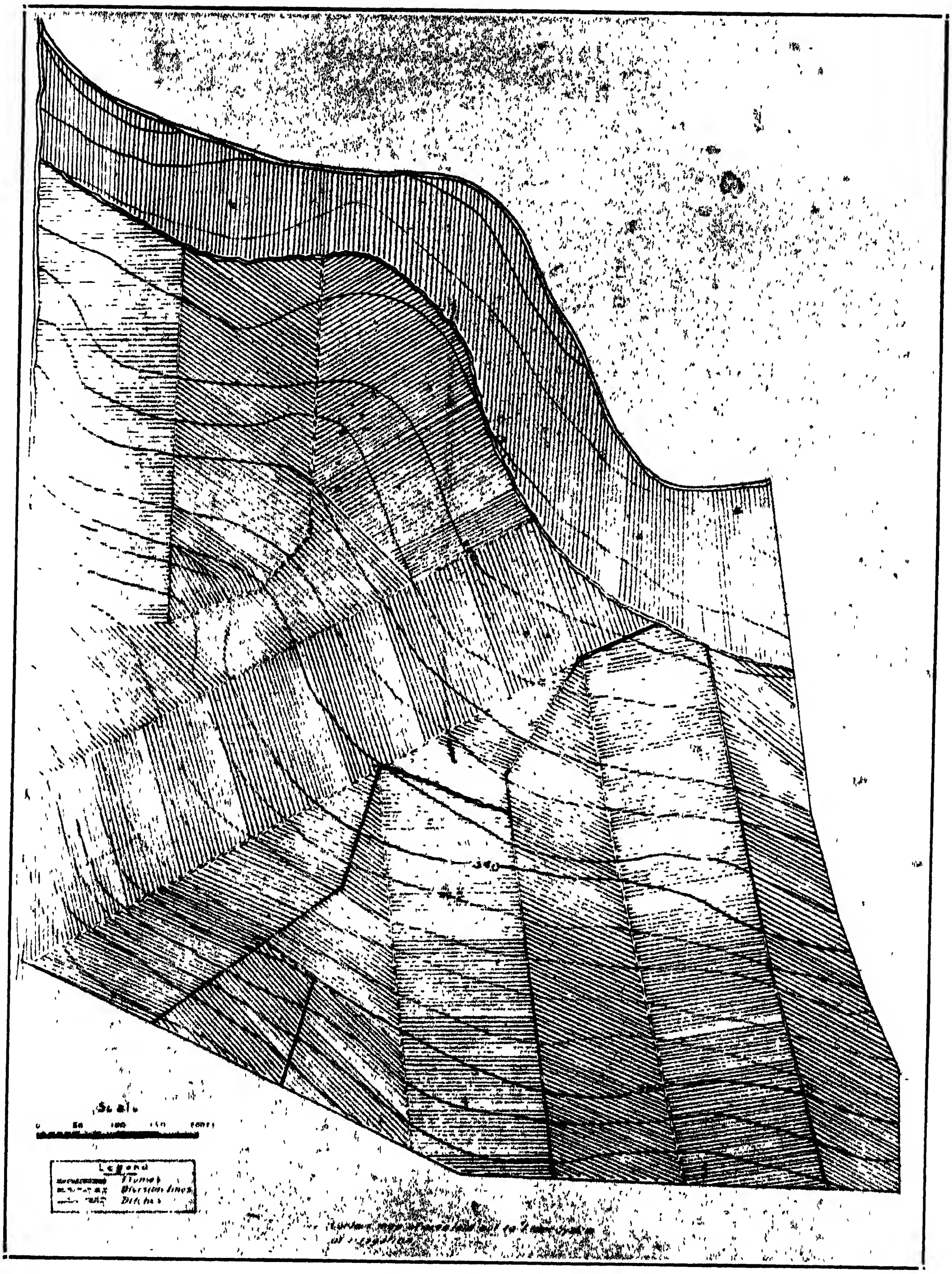


Fig. 9. Contour map of a cane field laid out under the flume system of irrigation.

COST OF FLUME SYSTEM: The costs given below are for the 27 acre plot. By improved methods we expect to reduce these costs materially on the field to be planted this year.

The irrigation costs include the cost to date plus an estimated cost of 28 more irrigations at $0.15 per acre per round.

	Cost per Acre
Furrowing	$ 2.50
Preparing and ditching	2.75
Planting	6.62
Irrigation	10.94
Weeding	16.33
Cultivating (includes horses at $0.50 per day)	6.89
Flumes ($27.40 per acre, distributed to three crops)	9.13
TOTAL ESTIMATED COST FOR THE CROP *	$ 55.16

Detailed Cost of Flumes:

Lumber	$544.60
Galvanized iron	36.00
Labor complete in place	170.33
Total	$751.33
Cost per lineal foot of flume	$ .0975
Cost per acre	27.40

By carefully laying out the system on a two-foot contour map of the field we are to plant this year (Fig. 9) we have been able to reduce the amount of flume necessary to 170 feet per acre. This should cost about $17.00 per acre with the same price for lumber as last year, or a cost of $5.66 per acre if the flume cost is distributed to three crops.

* Cost of fertilizer and water omitted.

Liming.

By J. A. VERRET.

Niulii Mill & Plantation Co., Experiment 1,—1922 Crop.

Pepeekeo Sugar Co., Experiment 5,—1922 Crop.

We have recently harvested two experiments on Hawaii having to do with liming. One was in the Hilo district at Pepeekeo and the other in the Kohala at Niulii. The cane in both cases was Yellow Caledonia.

The soil in the experimental area at Pepeekeo was rather highly acid, requiring two tons of quicklime to neutralize the upper ten inches of soil. The Niulii soil was not sampled at the time the experiment was put in, but other soil samples from this plantation show about twice as much available lime as do the soils in the Hilo district.

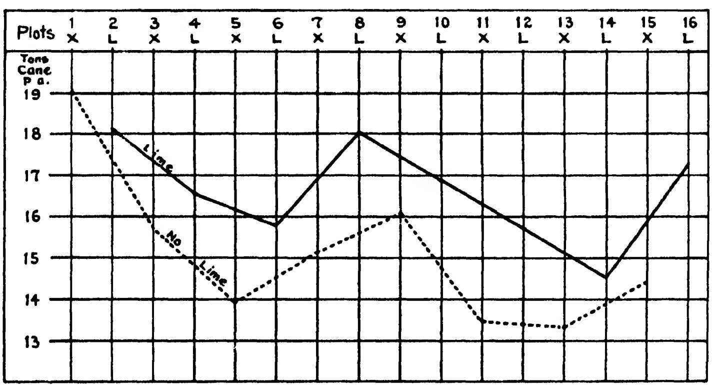
In both cases all plots received uniform fertilization, corresponding to that given to the rest of the field by the plantation.

The amounts of lime used and the results obtained are given in the two following tables:

LIME EXPERIMENT

Niulii Mill & Plantation Co Exp. 1, 1922 Crop

Field 28 Makapala



NIULII EXPERIMENT 1—LIME.

Treatment	Yield per Acre		
	Cane	Q. R.	Sugar
Two tons Waianae lime	16.7	8.65	1.92
No lime	15.2	8.43	1.80

PEPEEKEO EXPERIMENT 5—LIME.

Treatment	Yield per Acre		
	Cane	Q. R.	Sugar
Four tons lime per acre	50.1	7.70	6.51
Two tons lime per acre	49.4	7.74	6.39
No lime	51.7	7.94	6.52

The rather low yields at Niulii were due to two bad years in succession when the cane suffered severely from drought. Dry weather made it necessary to replant this field twice.

The returns at Niulii, although small, were consistently in favor of lime—that is, all the lime plots were a little bit better than the adjoining no lime plots. But although these gains are consistent, they are too small to be profitable unless the beneficial effects of the liming are continued for several crops.

Under good weather conditions with bigger yields, the gains from liming might have been larger and economically profitable.

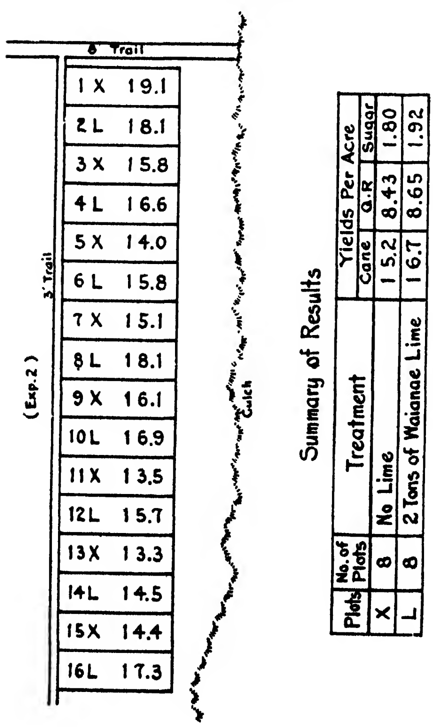
We plan to continue this test for several crops, without further additions of lime, to determine how long the original lime is effective and to note the total sugar gained from this amount of lime.

The results obtained at Pepeekeo did not follow those obtained at Niulii, in that there were no increased yields from the lime plots.

LIME EXPERIMENT

Niulii Mill & Plantation Co Exp.1, 1922 Crop

Field 28. Makapala.



As a whole, our lime experiments to date have given negative rather than positive results. Even in the few experiments which show gains, these gains have generally been too small to be profitable. Plantations which do not fertilize heavily would get much higher returns for the money spent by buying nitrogen rather than lime.

Before any extensive liming operations are started, they should be preceded by a thorough investigation of the returns to be expected.

Details of Experiments.

NIULII MILL AND PLANTATION CO., EXPERIMENT 1,—1922 CROP.

Object:

To determine the value of applying lime in the Kohala district.

Location:

Niulii Mill and Plantation Co., field 28, Makapala.

Crop:

Yellow Caledonia, plant cane (August 10, 1920).

Layout:

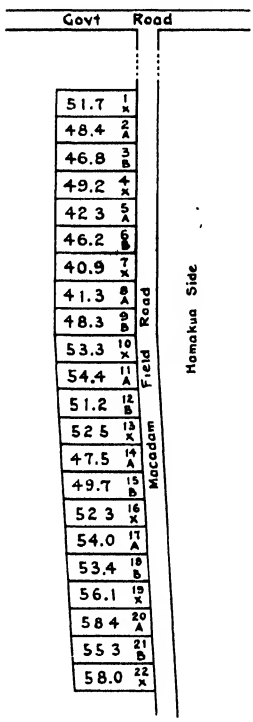
Number of plots = 16.

Size of plots = 1/20th acre, consisting of 6 lines, each line 4.7 feet wide and 78.55 feet long.

LIME EXPERIMENT

Pepeekeo Sugar Co. Exp. 5, 1922 Crop

Field 1B.



Summary of Results

Plots	No of Plots	Treatment	Yields Per Acre Cane	Q.R.	Sugar
X	8	No Lime	51.7	7.94	6.52
A	7	2 Tons Lime Per Acre	49.4	7.74	6.39
B	7	4 Tons Lime Per Acre	50.1	7.70	6.51

Plan:

Odd plots (X) = no lime.

Even plots (L) = 2 tons of lime per acre.

Fertilization:

Uniform to all plots according to the following schedule:

January 28, 1921 — 500 lbs. of High Grade per acre.

June, 1921 — 250 lbs. of Nitrate of Soda per acre.

High Grade = 12% N, 6% P_2O_5, 1% K_2O.

Experiment planned by J. A. Verret, W. P. Alexander and W. L. S. Williams.

Experiment laid out by H. L. Denison.

Experiment harvested by W. C. Jennings.

PEPEEKEO EXPERIMENT 5,—1922 CROP.

Object:

To determine the value of lime on acid soil.

Location:

Pepeekeo Sugar Company, field B.

Crop:

Yellow Caledonia, plant cane.

Layout:

Number of plots = 22.

Size of plots = 1/10 acre, consisting of 6 lines, each 5.75 feet wide and 126.84 feet long.

Plan:

Plots	Number of Plots	Plot Numbers	Treatment
X	8	1, 4, 7, 10, 13, 16, 19, 22	No lime
A	7	2, 5, 8, 11, 14, 17, 20 ...	2 tons per acre Waianae lime
B	7	3, 6, 9, 12, 15, 18, 21 ...	4 tons per acre Waianae lime

Fertilization:

Fertilization in Pounds per Acre.

Plots	September 1, 1920	November 1, 1920
All	375 lbs. B-7	375 lbs. B 7

B-7 = 11% N, 6% P_2O_5, 6% K_2O.

Soil Analysis: Colorimetric method — lime requirement to bring to immediate neutrality — 2 tons Waianae lime per acre. Recommended application to maintain at neutral point — 3 to 4 tons Waianae lime per acre.

Experiment planned by J. A. Verret, W. P. Alexander and W. L. S. Williams.
Experiment laid out by W. L. S. Williams.
Experiment harvested by H. K. Stender.

The Maui Progenies.

By W. W. G. Moir and E. L. Caum.

The briefly summarized data presented below were obtained from experiments planned and laid out by the writers, and carried on by them with the cooperation of the Maui Agricultural Company and the Wailuku Sugar Company. The work to date divides naturally into four parts, corresponding to the four years 1919 to 1922, but for the sake of convenience the progress on the individual experiments is detailed from the beginning to the present time, instead of each year's work being dealt with as a unit. In the beginning, the different experiments were numbered, each number being preceded by the letter S, an abbreviation of Selection. Later this system was discontinued, the progenies from the various experiments being combined into two groups, corresponding to the two plantations, and each group numbered consecutively.

Experiments S 1 to S 5 were planted in the Seedling Nursery, Hamakuapoko Section, Maui Agricultural Company; S 6 in Field 96, and S 7 to S 16 in Field 95, Wailuku Sugar Company.

EXPERIMENT S 1. Early in 1919, H. D. Sloggett, then in charge of the Hamakuapoko Section of the Maui Agricultural Company, cut a number of eyes of H 109 cane, choosing large eyes from big sticks. These eyes were germinated in pots made from shingles, and on May 12, fifty were set out in Field 4, spaced about a foot apart in the row. These plants were not given any special treatment, being handled under the normal plantation method.

On May 28, 1920, the forty stools remaining from Mr. Sloggett's original planting were cut, data being taken on the number of sticks, suckers and shoots per stool, relative size, and vigor of growth. The seed from these stools was planted end to end, with an 18-inch space between progenies. In all cases every stick of each stool was cut for seed, the entire stool being used for this purpose. Observations made during the year showed great variation among the progenies of the several stools, and in 1921, after one year's growth, the difference in tonnage of cane in some cases was over 200%. A survey was made, and stools selected from eighteen of these progenies for planting in the progeny-test area at Hamakuapoko. Data were taken on the number of sticks per stool, relative size of sticks, and the color and growth types.[1] The forty original progenies were ratooned for further study. The eighteen selected stools were given consecutive numbers in the new progeny planting mentioned above, and the later work on this planting will be dealt with further on.

[1] H 109: A Study in Variation. Haw. Pl. Rec. XXV, pp. 269–281. (Dec., 1921.)

EXPERIMENT S 2. On June 2, 1920, ten stools of H 109, each very uniform for size of stick and with a minimum of eight sticks each, were cut in Field 4, M. A. Co. The standard used in selecting these stools was exceedingly high for this field, which is one of the oldest on the plantation, and is heavily infested with nut-grass. Data were taken on the number and relative

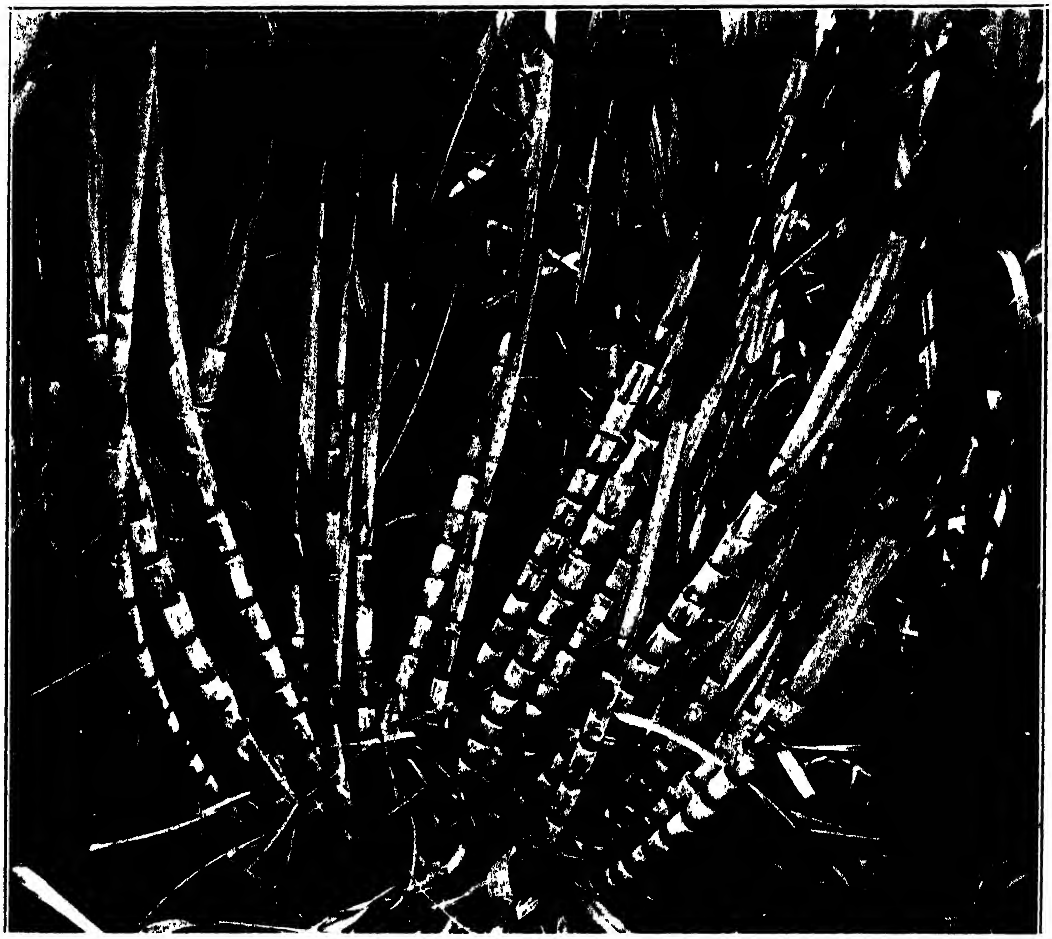


Fig. 1. A first ratoon stool from a single eye, at one year of age.

length and diameter of sticks, and position of the stools in the field, as regards ditches, water-courses, etc. Density readings of juice samples from each stick were made with the refractometer. Each stick of each stool was then cut for seed and planted. The seed-pieces from each progeny were sorted out according to the number of eyes on each, and those of a like number of eyes planted together. These seed-pieces were spaced about ten inches apart in the row, with a larger space separating the series of four-eye cuttings, for instance, from the three-eye series. A space of two and a half feet separated progenies.

In 1921 a survey was made and differences noted between progenies as regards type of growth and uniformity of stand, as well as in the comparative value of the progenies as a whole. Stools were selected from six of these for planting in the progeny test area, the other four being discontinued. They were all

good stools from good progenies, differing in this respect from those chosen from S 1, which in some cases were good stools from mediocre progenies. Spacing the seed seemed to have a tendency to induce stooling. As a general rule only two or at most three eyes per seed piece germinated, indicating that there is no advantage in the use of seed pieces with a greater number of eyes. Correlated with this there is a disadvantage in the unnecessary amount of cane planted. These progenies also were allowed to ratoon.

EXPERIMENT S 3. On June 3, 1920, twelve sticks of plant H 109 and six of ratoon Lahaina were cut, data being taken on the degree of uniformity of the stool and the absolute size of the stick. These sticks were then cut into single-eye seed-pieces, and each eye planted, the pieces being spaced eight inches apart, and arranged in the order of their occurrence on the stick.

On the 1921 survey it was noted that only twenty eyes of the three hundred and eighty-six planted failed to germinate, a failure of less than 5%. These twenty failures were scattered throughout the length of the sticks, being grouped neither near the butts nor the tops. In only two cases did the extreme bottom eye, and in no case did the extreme top eye, miss. On the whole, the fourth to the eighth eyes from the top of the stick germinated most rapidly. (In one-year cane this would be about the second seed under plantation cutting.) These were followed by the uppermost eyes and the eyes immediately below, which came up together, and then gradually by the rest, the butt eyes being the last to show. The resulting differences in height, while very marked at first, were no longer noticeable after a few weeks. At the time the selection for planting in the progeny test area was made it was noted that the stools arising from sticks taken from uniform stools were on the whole better than those from sticks taken from irregular stools, but that the position of the eye on the stick had no effect on the size of the stool arising from it. Seed from six of these 366 stools was planted in the progeny test area, five of H 109 and one of Lahaina. The rest were discontinued.

EXPERIMENT S 4. Ten small, scrubby sticks of H 109 were chosen from very irregular stools. The other sticks of the stools, while generally of mixed sizes, were always larger than the stick chosen. These sticks were cut into normal sized seed-pieces before planting. This planting was done on June 3, 1920.

On the 1921 survey it was noted that the stools resulting from these small sticks were on the whole very irregular, but four uniformly good stools, one each from four progenies, were selected for planting in the progeny test area.

EXPERIMENT S 5. This experiment, which was planted on June 4, 1920, was designed to test the comparative value of selecting uniformly large stools for seed, as against selecting large sticks regardless of the type of stool from which they are taken. In the stools selected the sticks, always six or more in number, were of a uniform size. The single sticks taken as a check were of the same size as those in the uniform stools, but were taken from very irregular stools. Not more than one stick was taken from any one of these irregular stools, while in the uniform stools all the sticks were taken. Each stick was cut up into seed-pieces, body seed being used as in the previous experiments.

Fig. 2. Erect type.

Fig. 3. Semi-erect type

In 1921, a count of the total number of sticks per line showed no advantage either way, but the lines planted with seed from uniform stools were much more uniform than those planted with seed from irregular stools. A few stools were selected for planting in the progeny test area.

In January, 1920, about 125 more single eyes of H 109 were cut and started, great care being taken in choosing large parent sticks from several stools. It should be noted here that these single-eye cuttings were made by simply gouging out the eye without destroying the stick, which was left standing. In later work this method was changed, the stick being cut up into pieces, each bearing one eye. In the middle of April one hundred of these plants were set out, spaced two and a half feet apart in the row. This planting was not given an S number.

In 1921, twenty-one of these 100 stools were chosen for further progeny planting, data being secured on the number of sticks per stool, relative size and vigor of same, and color and growth types. Tremendous differences were noted, particularly in type of growth. These stools were ratooned, and in 1922 the young ratoons demonstrated these differences to an even more marked degree than did the original stools. Figure 1 shows one of these first ratoon stools.

All the stools selected from these Hamakuapoko experiments were given consecutive numbers in the new progeny test planting, regardless of the experiment from which they were taken. All these progeny plantings were made from three-eye cuttings spaced one foot apart in the row. It might be noted that the space given over to these plantings had been cropped with cane for many years, and more recently had been planted to sweet potatoes. This is mentioned simply to show that any exceptional stand is due to the canes themselves and not to any especially favorable treatment. After making the selections in these Hamakuapoko experiments, all the H 109 cane not planted in the progeny test area, discontinued progenies as well as discarded seed from continued progenies, was planted as crop cane in Field 94, Keahua Section, M. A. Co.

In 1922, a careful survey of the progeny planting was made and data collected. Due to press of time, no tonnage figures were obtained. A few refractometer readings were made, but because of the fact that the instrument was in bad shape, this part of the work was not continued.

Of the 2445 stools comprising the 65 progenies in the test area, 510, or about 21%, were selected for further planting. Only two progenies were discarded entire. Twelve new stools of H 109 were added from the crop cane at the ends of the water-courses, making a total of 522 stools of 75 progenies, which planted about five acres of the extended progeny test area in Field 3. Seventy-four of these progenies are of H 109, the other one being of Lahaina, a stool of which, originally from S 3, seemed in addition to other good qualities to be resistant to root-rot or Lahaina disease.

These progenies were of several types, and the differences between these types were striking. In nearly every case the type characteristics were found to be inherent — that is, the progeny harvested in 1922 was very similar to the mother-stool of 1921. These differences were so obvious in many cases that they were plainly apparent to the casual observer. The Lahaina progeny that

Fig. 4. Recumbent type. This type does not show its recumbent character from the beginning, but the slender, weak shoots will indicate the slender, weak sticks to follow.

Fig. 5. Recumbent bird's nest type.

had attracted attention last year continued to produce good stools, but not sufficiently good to compete in tonnage with the adjoining H 109 progenies.

The ratoons of the 1920 planting were not cut, the plan being to obtain tonnage and juice figures on mature cane, as well as to afford an opportunity for the study of progenies at two years of age.

EXPERIMENT S 6. On June 8 and 9, 1920, a large amount of one-year plant H 109 was selected and cut in Field 91C, Wailuku Sugar Co. The stools chosen, none of which had less than six sticks, were all uniform — that is, the sticks in a given stool were all of approximately the same size, the variation in diameter being negligible. The length, of course, varied with the age of the sticks. The stools were, naturally, not absolutely uniform with each other, some being composed of smaller sticks than others, but an attempt was made to get stools which were approximately uniform with each other. The sticks were generally large, above the average for H 109 of this age. This cane was planted June 9, in Field 96. The plot was intended to serve as an observation test, or as a seed plot if the quality of the cane was markedly better than that of the rest of the field. It was not a progeny planting.

In 1921 the cane on this plot was stripped and a general inspection made. It was found that, while the number of sticks per line was no greater than in the regular plantation cane, they were more uniform and of better size. This experiment showed that carefully chosen seed carefully handled will give a better yield than seed cut and handled in the usual haphazard fashion. This area was used as an observation test only, and no seed was cut or further data taken.

EXPERIMENT S 7. This consisted in an observation test on the growth of exceedingly stunted sticks of late Striped Mexican replant cane in an H 146 field. The stalks taken for seed were less than one-half inch in diameter, and each constituted the only stalk arising from its seed-piece, which in each case was of more than average size.

In 1921 it was found that the stunting in question was purely environmental, the sticks giving rise to normal stools, some of which would pass any reasonable standard set up for original field selections.

EXPERIMENTS S 8 AND S 9. These experiments, which were planted on June 15, 1921, may well be considered together, as the plan and layout were identical, the difference being in the variety of cane employed. S 8 was planted to H 109 and S 9 to Lahaina. They were designed to test the comparative value of selected seed against the regular plantation seed. As in the case of S 6, each stool chosen was composed of uniform sticks, but the stools were not necessarily uniform with each other, although they were as nearly so as possible. As there was neither sufficient seed nor sufficient space available to lay out an experiment on the checker-board plan, the selected seed and the seed furnished by the plantation were planted in alternate lines. The plantation seed was top seed only, while that from the selected stools was top, body and butt seed mixed.

In 1921 it was found that the stand in these experiments was very irregular, due to the fact that considerable hard seed was used, and they were discontinued. However, five stools, four from S 8 and one from S 9, were selected for planting in the progeny test area in Field 100. Another fact which made it

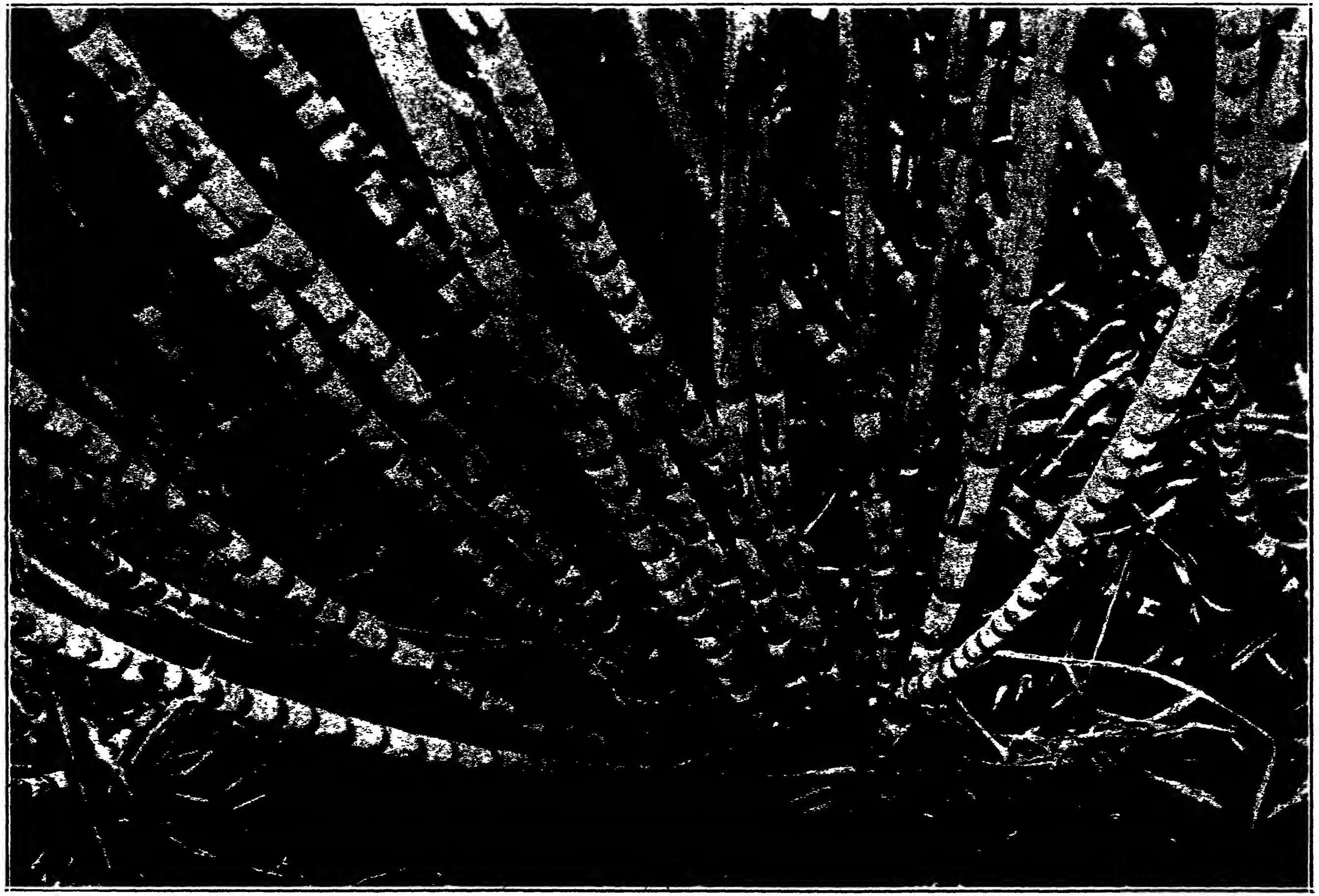


Fig. 6. A choice stool of H 109, consisting of seventeen sticks, grown from ordinary plantation top seed.

seem undesirable to continue these experiments was the discovery that the material used, both plantation and selected seed, was a mixture of several types of each variety. This was quite striking in the case of the Lahaina in S 9.

EXPERIMENT S 10. On June 22 to 24, 1920, about 200 stools of one-year H 109 were cut in Field 91 and planted. The stools chosen were practically all large and uniform. Six sticks per stool was the minimum, unless the sticks were exceptionally good, in which case a stool of five sticks was allowed.

In 1921 this area was gone over carefully and 71 stools selected for further progeny test planting. The stand in this experiment was very uniform, and the stools were well developed. The standard used in selecting these 71 stools was exceptionally high, and many striking type specimens were found.

EXPERIMENT S 11. This experiment, planted in June, 1920, was a replica of S 10, on a smaller scale, except that the cane variety employed was Striped Mexican. A few stools only were chosen, and planted next to S 10.

In 1921 it was found that only two stools in this area were of sufficient value to warrant replanting as progenies, partly because of the numerous Rose Bamboo mutations present.

EXPERIMENT S 12. This was a progeny planting of one stool of D 1135, which consisted of ten very large and uniform sticks and one large sucker. The seed from this stool was planted in June, 1920.

In 1921 it was found that, as the seed had not been spaced, and as the progeny was a prolific stooler, the sticks were quite small, although very numerous. This progeny was left for further observation, but a fire destroyed the material and further work was of necessity postponed.

During July, 1922, H. B. Penhallow, Manager of the Wailuku Sugar Co,, had the ratoon crop of this progeny cut and extended to a little over half an acre, spacing the seed a foot apart. The new stand arising from this spaced planting gives promise of being of great interest, as the young shoots are exceedingly strong.

EXPERIMENT S 13. This was a progeny planting of one stool of H 109 which consisted of 23 sticks. A photograph of this stool is shown on the cover-page of the Record for December, 1921. The cane was planted in June, 1920.

In 1921, four stools, superior to the rest in size and uniformity, were selected and included in the progeny test planting in Field 100. The remainder was left for observation, but was destroyed by a cane fire.

In 1922 the first ratoon crop was cut by the plantation and extended to a half acre, the seed being spaced one foot apart. This progeny maintained its distinctive characters, producing a somewhat erect and heavy stand of cane. The ratoon crop on the original stool in Field 91 was cut and planted in the extended progeny test area in Field 67, Wailuku Section. This ratoon stool consisted of 31 sticks, very much like the 23 sticks of the original stool.

EXPERIMENT S 14. This experiment, planted June 28, was a progeny planting of one stool of Yellow Caledonia, consisting of 23 very large and uniform sticks,

Fig. 7. A fine stool of Lahaina, consisting of twenty-three sticks, grown from ordinary plantation top seed.

Although a fast grower and a heavy stalk producer, this progeny did not reproduce the large stools in 1921, probably on account of close planting. This progeny was not continued as a plant crop, due to the cane fire mentioned above, but the ratoons were continued for further study and were extended to a half acre in Field 89.

EXPERIMENT S 15. This was a small observation test on the use of small sticks for seed. The cane was the so-called D 1135 type of H 109, averaging about ¾ inch in diameter. It was planted in July, 1920.

On the survey in 1921, it showed that small sticks are exceedingly poor planting material. Less than half of the seed germinated, and the stand was very open and irregular.

EXPERIMENT S 16. This was a progeny planting, made in July, 1920, of a very irregular stool of H 109. The entire stool was cut for seed.

In 1921 it was noted that the stand was very poor, the experiment tending to show that progeny plantings should be made from uniform stools only.

In addition to the 82 progenies taken from Experiments S 8, 9, 10, 11 and 13, eight new Lahaina and ten new H 109 progenies were planted in the progeny test area. All seed was spaced a foot apart in the row. The butts and hard seed from these progenies were planted as crop cane along the level ditches. A few photographs showing the different growth types of these progenies were published in the Record for December, 1921. As explained there, those photographs showed the cane at the age of three and a half months. In 1922, when the cane was one year old, the different types of growth were even more apparent than in the young cane.

In June, 1922, a careful survey of all progenies was made, data being taken on color and growth types and on the relative value of each progeny as a whole. Of the 3603 stools comprising these 100 progenies, 420 of H 109, or approximately 14%, and 64 of Lahaina, or about 11%, were selected for further progeny planting. Seven progenies were discarded entire. These 484 stools were planted in Field 67. Thirty new stools of H 109 were added from the crop cane along the ditches, and 42 were selected from fourth ratoons in Field 81. These latter progenies will be followed with particular interest, as they practically all represent one type, and from the size and vigor of the stools selected, this type appears to be very desirable.

Here at Wailuku, as at Hamakuapoko, very striking type differences were found among the progenies, and it was possible to correlate certain growth types with stalk and color characteristics. The Lahaina progenies carried on, although not absolutely characteristic of the variety, seem to represent a superior strain, quite distinctive at certain stages of growth. These Lahaina progenies, together with the one at Hamakuapoko, represent the only selections that have been made in this variety, except for the new ones added at Keahua this year, which will be described later.

All told, there were 167 progenies planted in the Wailuku test area. In addition, a little more than an acre of Lahaina was planted with choice top seed spaced a foot apart, to afford a good opportunity for selection next year.

Fig. 8. An exceptional stool of H 109, consisting of twenty-five sticks, all apparently arising from a single eye.

It might be mentioned here, before describing the 1922 selection work at Keahua, that the Wailuku Sugar Co. is cooperating in this project to the best of their ability, and are carrying on a number of independent experiments along similar lines. They have planted about twelve acres, using Lahaina, H 109, D 1135 and Striped Mexican, involving single eyes spaced 18 and 24 inches, single eyes (Cuban type) spaced 18 and 24 inches, and plantation seed spaced 1 and 12 inches. All the seed used was of excellent quality.

The following quotation is from a letter from H. B. Penhallow, dated August 12, 1922: "Besides the progeny plots which you have planted from time to time, we have planted from the stools selected by you for further observation all the seed you left uncut, in a mixed planting in Field 67. That is, we made no attempt to keep the seed from each stool separate. From the remainder of the progeny fields in 95 and 100 we made a stalk selection, rejecting all undersized cane, and have been able to plant about 40 acres of such selected H 109 in addition to the above. Field 89, in which this years' Experiment Station is located, has been planted with stalk selected Lahaina, and 16 acres in Field 71 with the same, making a total of 66 acres of selected Lahaina. Four acres of stalk selected D 1135 were also planted in Field 71, in addition to that in Field 89. All of this should give us excellent material to work in for further selection next season and furnish good seed for more extended plantings of all the above mentioned varieties. In fact we will have enough such seed for our entire plant area next season, barring circumstances beyond our control. All seed planted this year was far more carefully selected than was the previous practice — all undersized stalks being rejected."

Figures 2, 3, 4 and 5 show some of the different growth types exhibited by stools of H 109 arising from single eyes. The particular specimens photographed were chosen from a large block planted March 10, 1922, by G. B. Grant, at the request of the Wailuku Sugar Co. The photographs were taken June 16.

The summer of 1922 saw the beginning of the selection work in the Keahua section of the Maui Agricultural Co. Approximately 800 stools of H 109 and 300 of Lahaina were selected and marked for cutting in Field 94. About two-thirds of the H 109 stools chosen were in the area previously mentioned as having been planted with the discarded seed from Hamakuapoko. Figures 6, 7 and 8 show three of the stools selected at Keahua, the third one being a stool from the Hamakuapoko "discards." These 1100 stools were cut and planted as progenies the latter part of June.

During July, 1922, some 900 stools of H 109 were selected from one of the best fields on the Puukolii section of Pioneer Mill Co. These stools, which included many good type specimens, have been cut and planted as progenies by the plantation.

Since this report is intended to cover all the Maui progenies, it would be well to mention the share taken by the Olowalu Company in the project. In the fall of 1921 fifty-six stools of H 109 were selected by Mr. Grant from the fields of the Wailuku Sugar Co. and planted at Olowalu. Choice seed of H 109 was secured from the Pioneer Mill Co. and planted in a block adjoining these progenies. In addition, the plantation has selected several hundred stools from their

own fields for a progeny planting. During the present year they have made selections in the block planted with the seed from Pioneer, as well as reselecting in the Wailuku material.

In conclusion it might be stated that in the writer's opinion, based on the data obtained thus far, a system of selection according to type characteristics seems to be the most speedy and practical method of arriving at the desired results.

D 1135 and Yellow Tip at Honokaa.

The Honokaa Sugar Company has supplied us with the results of a test which was recently harvested on that plantation, comparing D 1135 and Yellow Tip.

The cane was plant in an upper field at 1300 feet elevation. In this upper field the Yellow Tip gave better yields than did D 1135. This is in line with general results elsewhere. As a general rule, at elevations of 1200 to 1500 feet and up, Yellow Tip will do better than most other canes. A strong item in its favor is its good ratooning powers.

At the present time, the best results are being obtained on Hawaii by planting Yellow Caledonia at the lower elevations, D 1135 in the middle and the Tip canes at the highest elevations.

In former years the Tip canes found much favor in Hamakua, but they were forced out of cultivation, to a large extent, by Yellow Stripe disease.

Both Yellow Tip and Striped Tip are extensively planted in the Kohala district. Yellow Tip, especially, is being planted in the upper fields in the Hilo district. In neither of these districts are these canes suffering badly from Yellow Stripe at the present time.

We believe it both feasible and advisable to again try the Tip canes in the upper Hamakua fields. Good, sound seed should be obtained, preferably from Kohala, and a few fields planted for trial, very careful watch being kept in the meantime for Yellow Stripe, particularly when planting new fields. It is possible that by careful selection of seed Yellow Stripe may be kept in control and good yields of sugar obtained.

The results obtained in the Honokaa test are given as follows:

Plot No.	Variety	T. C. P. A.	Q. R.*	T. S. P. A.
1	D 1135	24.1	9.17	2.63
3	D 1135	25.46	8.54	2.98
4	D 1135	30.74	8.59	3.58
6	D 1135	26.85	8.43	2.69
7	D 1135	25.91	8.69	2.98
9	D 1135	23.8	8.96	2.66
	Average..	26.14	8.73	2.99
2	Y. T.......	32.39	9.36	3.46
5	Y. T.......	29.44	9.57	3.08
8	Y. T.......	32.95	9.56	3.45
	Average..	31.59	9.50	3.33

* Quality ratio based on first mill juices.

Within recent years a number of seedlings have been propagated from the Tip varieties. These are now under trial. Additional seedling work is contemplated, using Yellow Tip and Striped Tip as parent canes. By obtaining crosses between these varieties and D 1135, Badila, and other canes, we hope to secure seedlings that retain the vigor of growth at high elevations that is so characteristic of the Tip canes, combined with the resistance to Yellow Stripe disease commonly met with in varieties such as D 1135.

J. A. V.

Field Distribution Record of H 109.

Herewith is presented a graphic method of recording the field distribution of sugar cane varieties originated by H. B. Penhallow, Manager of the Wailuku Sugar Company and applied to H 109 for illustration.

The figures opposite the field numbers below the circles show the approximate percentage of seed used in planting a field where there was more than one source of supply. The heavy line connecting two circles shows the source of the largest quantity of seed used, or predominant strain.

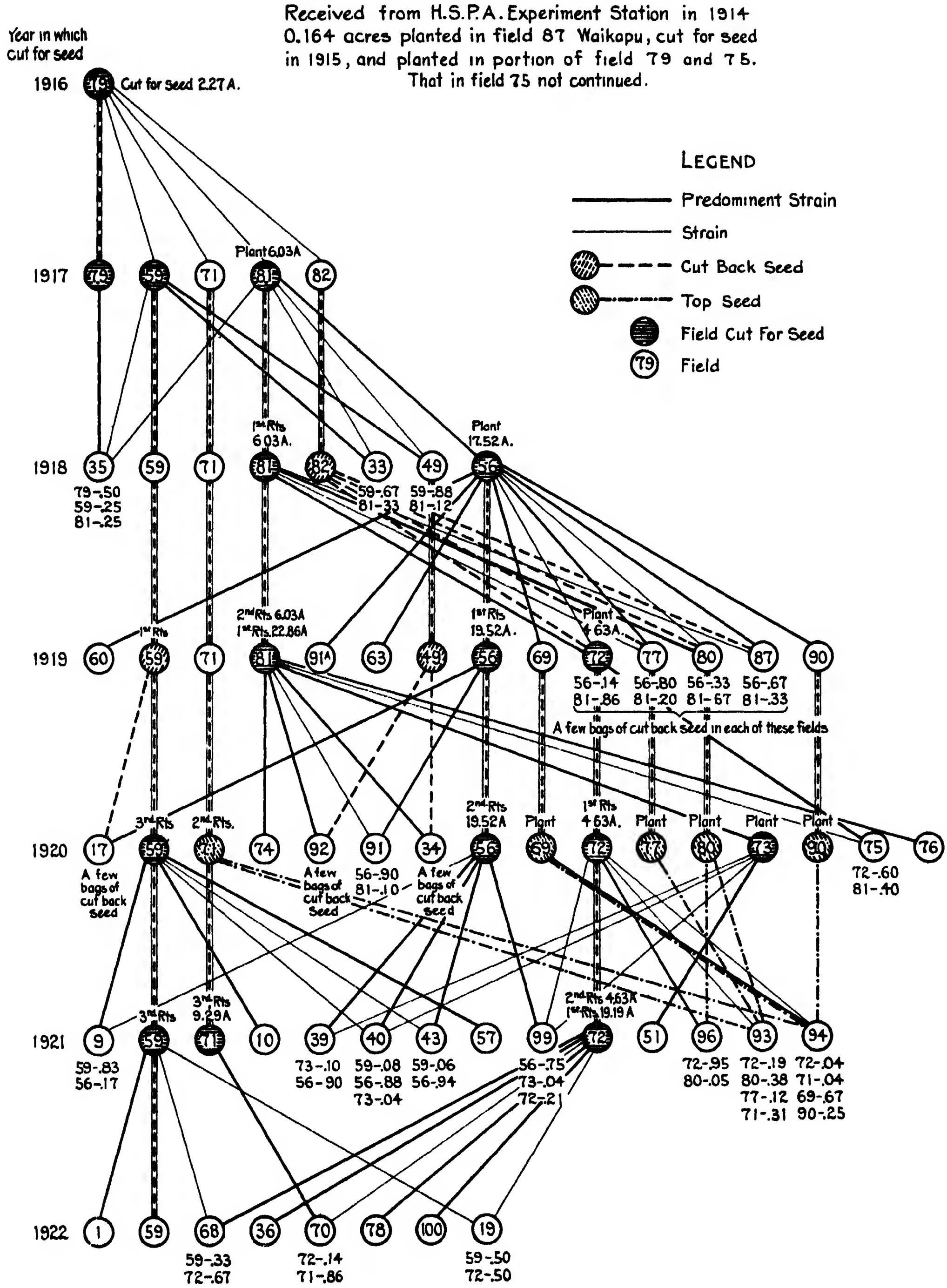
By referring to the legend on the chart the other types of lines will indicate the kind of seed used. Body seed was taken for planting, unless otherwise indicated by the line connecting the seed source with the field in which it was planted.

This graphic method can be used to good advantage in studying and recording the performance of selected canes and their progeny.

In addition to indicating the distribution, any other data may be recorded, as, for example, the tracing of the source of seed cane of outstanding fields — by recording the acreage yields or other notable features.

Field Distribution Record
H109 Seed
Wailuku Sugar Company

Received from H.S.P.A. Experiment Station in 1914
0.164 acres planted in field 87 Waikapu, cut for seed
in 1915, and planted in portion of field 79 and 75.
That in field 75 not continued.



Phosphoric Acid and Potash in Hamakua.

HAMAKUA MILL COMPANY EXPERIMENTS 3 AND 5,—1922 CROP.

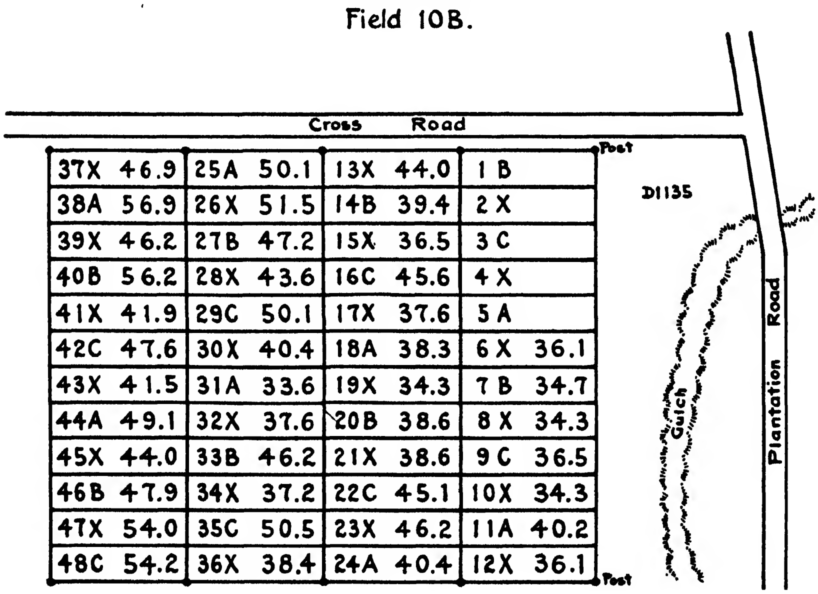
These two experiments were planned to determine the need of phosphoric acid and of potash at Hamakua.

Experiment 3 was laid out at Hamakua Mill in field 10B at an elevation of 1300 feet. Experiment 5 was in field 35, Kukaiau. The cane in both cases was plant, that in No. 3 being D 1135 and that in No. 5 being Yellow Caledonia. All plots received 155 pounds of nitrogen per acre from 1000 pounds of nitrate of soda. Some plots received no further fertilization; one series received 360 pounds of muriate of potash in addition; to another series 900 pounds of acid phosphate were added to the nitrate application. A fourth lot of plots got both the potash and the acid phosphate.

PLANT FOOD REQUIREMENTS

Hamakua Mill Co. Exp. 3, 1922 Crop

Field 10B.



Summary of Results

Plot	No. of Plot	Treatment			Yield Per Acre	
		N.	P_2O_5	K_2O	Cane	Sugar
X	24	155*	-	-	41.05	5.64
A	8	155*	-	150*	44.09	6.06
B	8	155*	150*	-	44.31	6.09
C	8	155*	150*	150*	47.06	6.46

At Hamakua Mill, in experiment No. 3, the results show a very definite response to both phosphoric acid and potash, amounting to about 0.40 ton of sugar for either one. The gain amounted to 0.90 ton of sugar when both of the ingredients were used on the same plots.

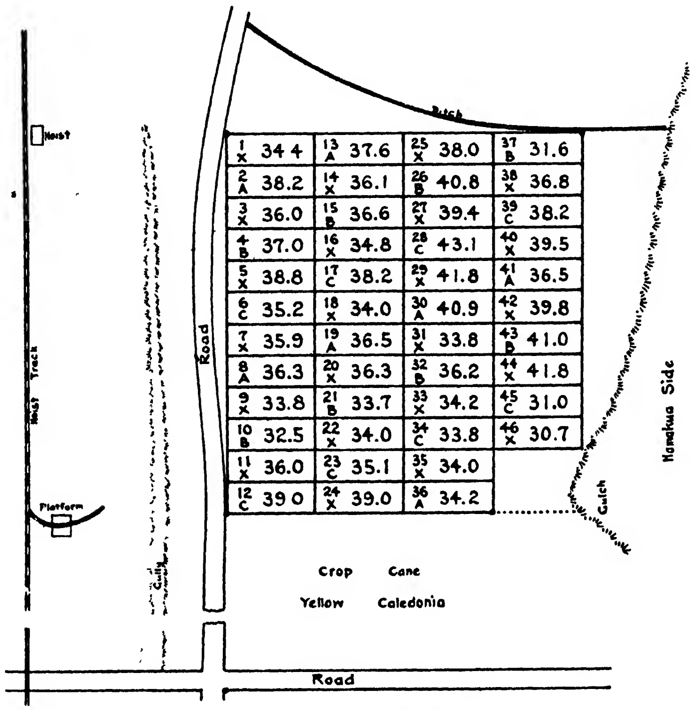
At Kukaiau, on the other hand, there was no response from either potash or phosphoric acid. The plots fertilized with nitrate of soda only gave yields just as good as did the plots where complete fertilizer was applied.

The results obtained from these two experiments are given in the following tables:

PLANT FOOD REQUIREMENTS

Hamakua Mill Co. Exp. 5, 1922 Crop

Field 35. (Kukaiau)



Summary of Results

Plots	No of Plots	Treatment			Yields Per Acre		
		N.	P_2O_5	K_2O	Cane	Q.R.	Sugar
X	23	155#	-	-	36.47	7.23	5.04
A	7	155#	-	150#	37.16	7.71	4.82
B	8	155#	150#	-	36.18	7.38	4.90
C	8	155#	150#	150#	36.71	7.78	4.72

HAMAKUA MILL EXPERIMENT 3, – 1922 CROP.

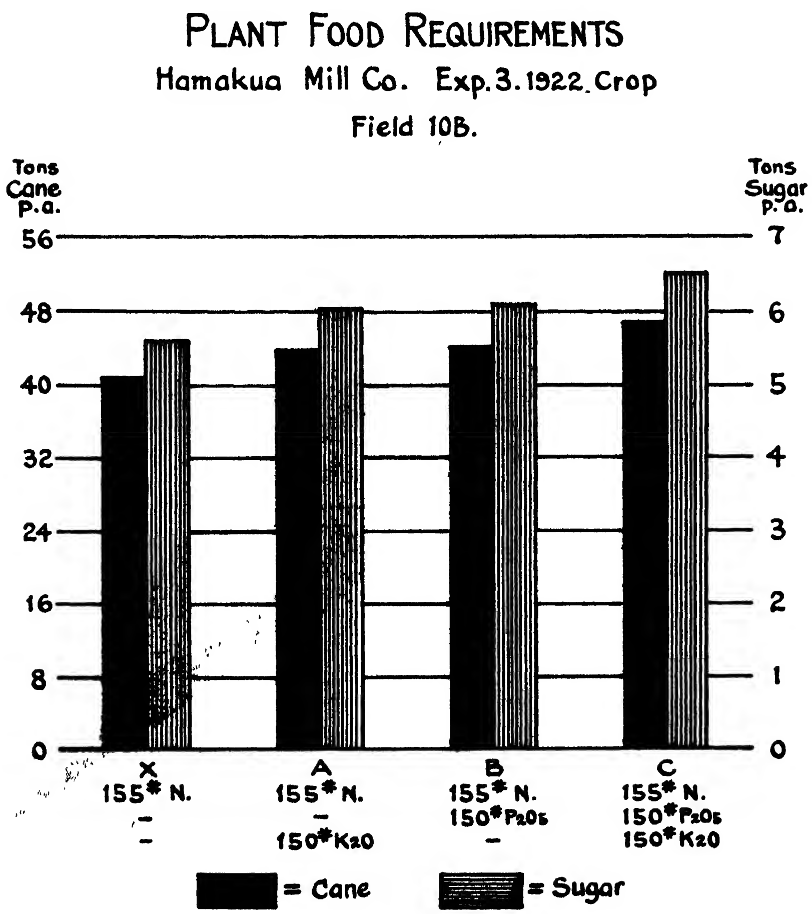
Treatment	Yield per Acre	
	Cane	Sugar
Nitrogen and phosphoric acid	44.3	6.09
Nitrogen only (adjoining plots)	41.4	5.69
Nitrogen and potash	44.1	6.06
Nitrogen only (adjoining plots)	41.4	5.68
Nitrogen, phosphoric acid and potash..	47.1	6.46
Nitrogen only (adjoining plots)	40.4	5.54

HAMAKUA MILL EXPERIMENT 5,—1922 CROP.

Treatment	Yield per Acre		
	Cane	Q. R.	Sugar
Nitrogen only	36.5	7.23	5.04
Nitrogen and phosphoric acid	36.2	7.38	4.90
Nitrogen and potash	37.1	7.71	4.82
Nitrogen, phosphoric acid and potash..	36.7	7.78	4.72

Details of Experiment.

HAMAKUA MILL CO. EXPERIMENT 3,—1922 CROP.



Object:

To determine the plant food requirement of sugar cane on the soils of Hamakua district. The comparison is made between:

(1) Nitrogen alone;
(2) Nitrogen and potash;
(3) Nitrogen and phosphoric acid;
(4) Nitrogen, potash, and phosphoric acid.

Location:

Hamakua Mill Co., Field 10B (elevation 1300 feet).

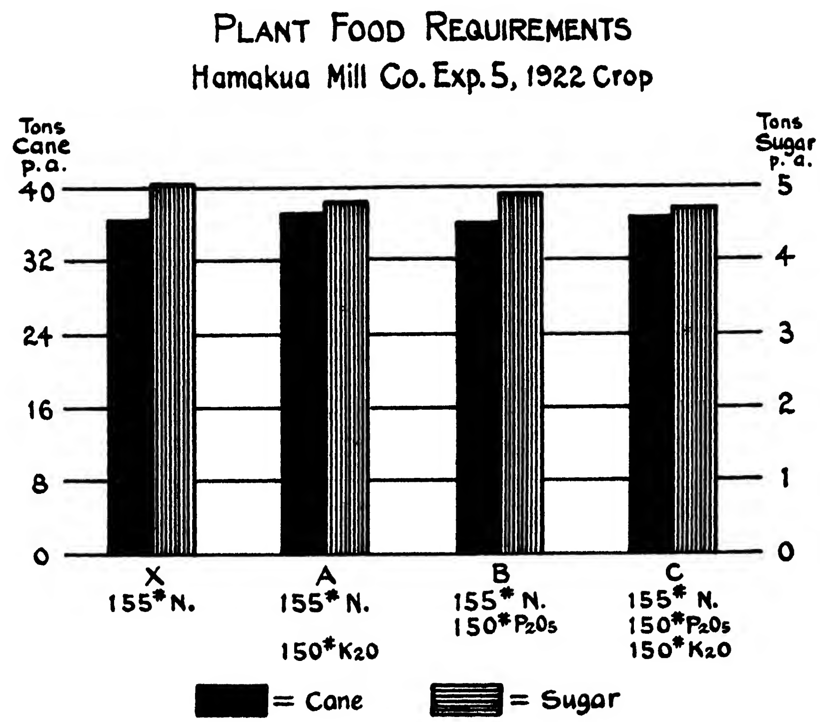
Crop:

D 1135, plant cane (planted March, 1920).

Layout:

Number of plots = 48.

Size of plots = 1/15 acre, consisting of 6 lines, each line 4.625 feet wide and 104.65 feet long.



Fertilization — Pounds per Acre:

Plots	Number of Plots	May 19, 1920		July 1, 1920	Nov. 1, 1920	Mar. 1, 1921	Total		
		Mur. Pot.	Ac. Pho.	N. S.	N. S.	N. S.	N.	K_2O	P_2O_5
X	24	...	....	300	400	300	155	...	...
A	8	360	....	300	400	300	155	150	...
B	8	...	900	300	400	300	155	...	150
C	8	360	900	300	400	300	155	150	150

Muriate of potash, 42% K_2O. Acid phosphate, 17% P_2O_5. Nitrate of soda, 15.5% N.

Experiment planned by J. A. Verret, W. P. Alexander and W. L. S. Williams.
Experiment laid out by W. L. S. Williams.

HAMAKUA MILL COMPANY EXPERIMENT 5, — 1922 CROP.

Object:

To determine the plant food requirement of sugar cane on the soils of Hamakua district. The comparison is made between:

(1) Nitrogen alone;
(2) Nitrogen and potash;
(3) Nitrogen and phosphoric acid;
(4) Nitrogen, potash, and phosphoric acid.

Location:

Hamakua Mill Co., Field 35 (Kukaiau).

Crop:

Yellow Caledonia, plant cane (planted April 15, 1920). Field fallow in 1919; 1500 pounds lime per acre applied before planting.

Layout:

Number of plots = 46.
Size of plots = 1/15 acre, consisting of 6 lines, each 5.25 feet wide and 92.2 feet long.

Plan:

Fertilization — Pounds per Acre:

Plots	Number of Plots	May 29, 1920		July 1, 1920	Nov. 1, 1920	Mar. 1, 1921	Total		
		Mur. Pot.	Sup. Phos.	N. S.	N. S.	N. S.	N.	K_2O	P_2O_5
X	23	...	...	300	400	300	155	...	...
A	7	360	...	300	400	300	155	150	...
B	8	...	900	300	400	300	155	...	150
C	8	360	900	300	400	300	155	150	150

Nitrate of Soda = 15.5% N.
Muriate of Potash = 42% K_2O.
Superphosphate = 17% P_2O_5.

Experiment planned by J. A. Verret, W. P. Alexander and W. L. S. Williams.
Experiment laid out by W. L. S. Williams.

J. A. V.

Phosphoric Acid in Cane Juices.

A Possible Indicator of Fertilizer Needs.

By Herbert Walker.

Summary.

The direct determination of plant-food ingredients in cane juices is suggested as a logical and easily applicable means of getting an approximate idea of the fertilizer requirements of cane soils. A large number of P_2O_5 determinations in crusher juices indicated that this element was fairly constant for a given field and, in general, for a given elevation, although marked differences existed between canes grown at different elevations, the lower fields producing juice containing the most P_2O_5. As a preliminary standard .020% P_2O_5 (grams per 100 cc. crusher juice) is suggested. Fields averaging above this figure probably contain sufficient available P_2O_5 for maximum cane yields; a lower figure calls for field experiments. Where juices run less than .010%, some phosphate should be applied as a precaution, even in the absence of experimental proof that it is needed. Similar work with potash is planned.

While it is generally recognized that carefully controlled field experiments afford the only reliable means of knowing the fertilizer requirements of a cane soil, quicker methods of getting this information are much to be desired. Soil analyses alone, except in the few cases of extreme deficiency of some element, are not of much value; the plant food may be there, but for some unknown reason, be it chemical, physical, or biological, may not be available to the plant. Soil chemists are still trying to devise methods of extraction which shall imitate plant-root action and yield a solution containing the available plant-food in soil.

A so-called "physiological" method of soil analysis has been suggested from time to time by various investigators, but does not seem to have been tried out to any great extent. According to this method the amount of plant food available in a soil is indicated (relatively) by ash analyses of crops grown in it. The difficulty in getting representative samples and reducing them to ash for analysis is probably one reason why this method, which otherwise appears very practicable, has not been more extensively worked out. This difficulty was partially overcome by Burgess,[1] who compared the analyses of final molasses from a large number of plantations and pointed out the fact that "there exists a definite relationship between the percentage of potash present in the soils of a given region and that found in the final molasses from that section." He further suggested that "where a mill consistently produces a molasses which carries less than 2.5% to 2.75% of potash, or where the molasses ash runs less than 20% to 22% potash, field experiments with potash fertilization, at different locations on the plantation, might be profitably made."

The relationship between low potash content of molasses and the need of potash fertilization has been partially confirmed. The majority of field tests

[1] Hawaiian Planters' Record, Vol. XIX, p. 421.

made throughout the Islands has shown little or no increased yield of sugar from the application of potash fertilizers. The few soils which have responded are from those districts whose final molasses runs much lower than the average in potash.

A serious drawback to the use of molasses analyses for other than very general conclusions is the difficulty of determining from what particular field a sample of molasses has been derived. The average output of a plantation might show it to be, on the whole, well supplied with potash even though certain fields were very deficient. Also, potash is the only element determinable by this method, since most of the nitrogen and phosphoric acid is eliminated in the process of manufacture.

A procedure which would appear to have most of the advantages and few of the disadvantages of plant ash or molasses ash analyses is the direct determination of plant food ingredients in the cane juice. Samples can readily be obtained from the crusher or first mill during the grinding season without in any way disturbing factory or laboratory routine. Nearly all factories make a practice of taking separate samples of juice from each field for brix and polarization, and portions of these can be set aside for plant food analyses. A crusher juice sample from a few cars of cane covers considerable field area and should be fully as representative as a composite soil sample from the same location. Theoretically this method, once properly correlated with fertilizer experiments in the field, seems very logical. Instead of trying to imitate Nature by extracting soil in the laboratory with weak acids, supposed to approximate the action of plant roots, we let the cane prepare its own "soil solution" and submit it to us ready made for analysis. That the relative amount of plant food actually taken up is in some degree a measure of its availability seems a reasonable assumption.

Establishing a numerical relationship between percentages of mineral constituents in cane juice and the fertilizer requirements of a field has yet to be worked out. It may or may not be possible. We have made a start at least at this plantation by determining phosphoric acid in the crusher juice from each field ground during the last two months of the season. Some seventy analyses were made, covering twenty-eight different fields. The analytical work was done by George B. Glick, chief chemist of this factory, using a method adopted by W. R. McAllep for phosphoric acid determinations in connection with clarification experiments.

VOLUMETRIC P_2O_5 DETERMINATION IN CANE JUICE.

(See Sutton's Volumetric Analysis.)

SOLUTIONS.

A — 10% NH_4OH.

B — Acetic Acid.

C — 10% Sodium Acetate.

Dissolve 100 grams sodium acetate in water, add 50 cc. glacial acetic acid and make up to 1 liter.

D — Standard Uranium solution. One cc. = 0.005 gm. P_2O_5.

This may be either acetate or nitrate. Thirty-five grams per liter is the approximate amount, using either salt. If nitrate is used add 50 cc. glacial acetic acid or a correspond-

ing amount of weaker acid per liter. Excessive exposure to light reduces this solution.
Standardize against tri-basic calcium phosphate.

Indicator. Powdered crystals of potassium ferrocyanide.

Procedure. To 100 cc. of juice add 1 cc. NH_4O H solution, acidify with acid and add 10 cc. of the sodium acetate solution. Titrate with the standard uranium solution using powdered potassium ferrocyanide on a drop reaction plate as an indicator. The solution will usually settle sufficiently to pipette off a small portion of clear liquid for the end point determination.

Nearly the whole of the uranium solution should be added in the cold and the titration finished in the hot solution (90–100° C.).

The method usually gives duplicate results on the same juice which vary not more than .002% P_2O_5.

After the juices from a few fields had been analyzed it became evident, first, that different samples from the same field usually showed very little difference in phosphoric acid, and, second, that there was a very decided difference between juices from different parts of the plantation. At least three crusher juice samples, taken on different days, were analyzed from each field, when possible.

A few examples of analyses from Wahikuli section will illustrate the variations in amount of phosphoric acid:

Field	I 8 L	H 8 P	E 5 P
Approximate elevation	50 ft.	200–300 ft.	800–900 ft.
Grams P_2O_5 per 100 cc. crusher juice..	.062	.023	.015
" " " " " " ..	.060	.025	.012
" " " " " " ..	.067	.023	.013
Average	.063	.024	.013

These figures are fairly typical of the plantation as a whole. The juices from fields nearest sea level are rather high in phosphoric acid, those from the central portion, up to about 500 feet elevation, are moderately well supplied, while the highest areas are lowest in phosphate. This tendency has been so uniform that in the case of the fields thus far examined it would be possible, with the aid of a contour map, to predict fairly well the amount of phosphoric acid to be expected in the juice from any field. Exceptions to this rule may be found in some of the red soils at the north end of the plantation. Most of the cane from these fields had been harvested before phosphoric acid determinations were started, but the two samples we were able to get ran rather low in phosphoric acid, although from a moderate elevation.

Interpretation of Results.

With so little data available, any attempt to draw fixed conclusions in regard to phosphoric acid requirements of all the fields tested so far would be dangerous. G. R. Stewart of the H. S. P. A. Experiment Station is analyzing a large number of soils from different sections of the plantation which, by comparison with juices from the same fields, may show relationship between phosphoric acid in the soil and that taken up by the cane.

Variety of cane, as between Lahaina, H 109, Striped Mexican and D 1135, apparently does not influence the amount of phosphoric acid absorbed, nor have we found any noticeable difference in this respect between plant and ratoon cane.

Our lower fields generally yield more cane per acre, but with lower purity juice, than the uplands. This is probably due to other causes than phosphoric acid. Most of the lower fields are irrigated with pump water of a rather high salt content, and have plenty of it, while the upper areas have a purer water supply, but are more dependent on weather conditions. The fields cited happen to be exceptions to the general rule that our lower fields give higher yields of cane. I-8, long ratoons, the lowest in elevation and highest in phosphoric acid, yielded only 39 tons per acre of Striped Mexican cane; H-8, plant, yielded 43 tons per acre of H 109 cane; and E-5, plant, yielded 72 tons per acre of Striped Mexican. The crusher juice from I-8 averaged 21.51 brix and 84.52 purity; H-8 was 19.82 brix and 86.73 purity, and E-5 was 20.39 brix and 90.44 purity, yielding 10.3 tons sugar per acre. Evidently this cane could not have suffered much from its lack of phosphoric acid. Its subsequent ratoon yields will be of interest.

The inference from results obtained in field E-5, that all soils capable of yielding .013% phosphoric acid to the juices of cane growing in them contain a sufficient supply of available phosphoric acid, may be premature; it certainly seems logical to reason that phosphoric acid is not the limiting factor in the case of I-8, with nearly five times as much in its juice, and probably not in H-8. Field experiments harvested last year from B-6 at about 400 feet elevation indicated little or no gain from phosphoric fertilization.

Neighboring fields at about the same elevation harvested this year had about .025% phosphoric acid in crusher juice.

We have lately laid out several plant food field experiments at higher elevations, which, when harvested, should help correlate phosphate needs with phosphates in the juice. It is quite possible that even the poorest fields on this plantation may have enough phosphoric acid for their immediate needs.

There is the further possibility that cane juices will always contain a certain minimum amount of P_2O_5 and that its lack in the soil will be followed by less cane yields rather than by a further diminution of P_2O_5 in the juice. A field test made by the Experiment Station at Oahu Sugar Company yielded a large increase in sugar by the application of 90 pounds P_2O_5 per acre to a soil containing 0.16% total HCl soluble P_2O_5 of which 0.0024% was soluble in 1% citric acid. Juices from the plots receiving no phosphoric acid contained .008% P_2O_5; those from plots receiving 90 pounds phosphoric acid per acre had .010% P_2O_5.

While we may never be able to conclude definitely from a juice analysis alone that a field needs phosphate fertilizer, a relatively high figure for P_2O_5 in the juice very probably will indicate that such fertilization is not needed, and thus by elimination help to locate field experiments where they are most necessary.

As a basis for future work along this line I would submit the following:

Soils yielding cane with a phosphoric acid content of more than .020% in its juice probably contain enough available phosphoric acid and are not in immediate need of phosphate fertilizers.

Where the juice contains less than .020% P_2O_5, phosphates may be advantageous. Field experiments should be made to determine this point.

Where the juice contains less than .010% P_2O_5, the soil will probably respond to phosphate fertilizers and their moderate use should be continued even though no immediate gains are shown by field trials.

An interesting correlation between field and factory work is worthy of note in this connection. Messrs. McAllep and Bomonti,[1] in their studies on clarification of cane juices, found that the completeness with which a cane juice may be clarified depends very largely on the amount of phosphoric acid it contains, and placed the approximate limit, below which clear settled juices are not apt to be obtainable, at .030% P_2O_5. According to this, the first aid to determine which fields need phosphates would be a consultation with the sugar boiler. Those fields which consistently yield well settled, brilliant, clarified juice may be dismissed at once as not in need of phosphoric acid, and more consideration may be given to fields whose juices clarify less readily.

In this paper special attention has been paid to phosphoric acid. The same line of reasoning would apply to the determination of potash and nitrogen in cane juices, although experience has shown that nearly all Hawaiian soils respond to nitrogen, while comparatively few are in need of potash. Mr. Glick is planning to work out a simplified method for potash in juices in order to find out what differences in this element, if any, our fields may show.

Pioneer Mill Co., Lahaina, Maui.

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[1] Hawaiian Planters' Record, Vol. XXVI, p. 122.

Badila and Yellow Tip at Kilauea.

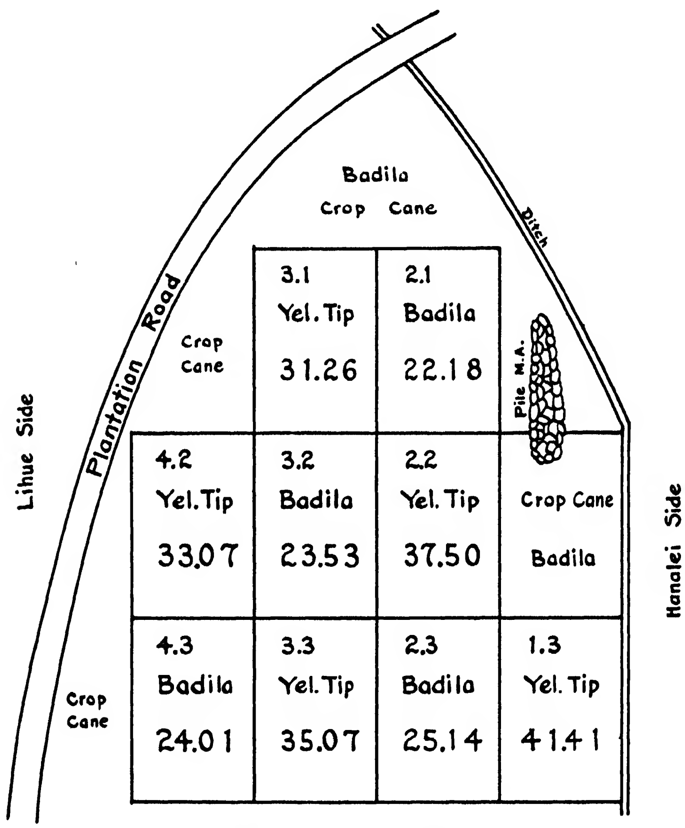
KILAUEA EXPERIMENT 32, — 1922 CROP.

In this experiment Badila and Yellow Tip varieties are compared in one of Kilauea's most mauka fields. The soil is poor and the climate is perhaps as bad for cane growing as at any place on the plantation.

VARIETY TEST

Kilauea Sugar Plantation Co. Exp. 32, 1922 Crop

Field 37.



Summary of Results

Plots	No. of Plots	Yields Per Acre		
		Cane	Q.R.	Sugar
Badila	4	23.71	9.54	2.48
Yellow Tip	5	35.76	9.98	3.58

The cane was planted in October, 1920. All plots received uniform applications of fertilizer at the rate of about 150 pounds of nitrogen per acre, 500 pounds of molasses ashes and 1000 pounds of raw rock phosphate per acre.

In the earlier stages of the experiment the Badila cane looked better than the Yellow Tip, but after about eight months ~~the~~ Tip cane seemed to get a somewhat better color and to hold it throughout the remainder of the growing period.

At the time the cane was harvested the Tip cane had a much heavier stand on the ground. It had stooled out more. It was apparently still growing while the Badila was fully matured. The Badila cane was badly rat eaten. A very high per cent. of the stalks was bitten off about half way up and the entire top half rotted or eaten on the ground. The Tip cane was far less rat eaten. If the rats could have been eliminated the Badila cane would have undoubtedly shown 50 per cent. higher returns.

The yields of cane and sugar are given in the following table:

Plots	Cane	Quality Ratio	Sugar
Badila	23.71	9.54	2.48
Yellow Tip	35.76	9.98	3.58

The Yellow Tip cane averaged 12.05 tons more cane and 1.10 tons more sugar per acre than the Badila. The experiment will be continued on the ratoon crop.

Details of Experiment.

Object:

To compare Badila and Yellow Tip varieties of cane on mauka, unirrigated land at Kilauea.

Location:

Field 37.

Crop:

Badila and Yellow Tip plant cane.

Layout:

Number of plots = 9.
Size of plots = 1/10th acre (80.6′ x 54′).
Plots consist of 12 straight lines each 80.6′ by 4½′.

J. H. M.

Notes on the Results Achieved to Date in the Introduction to the Fiji Islands of Certain Parasitic and Predaceous Insects.

By Robert Veitch.

Since 1911 a number of parasitic and predaceous insects have been introduced to the Fiji Islands for the purpose of controlling the more important pests, and the time now seems opportune for recording the results achieved in these various introductions.

In 1911 the late Mr. Terry sent two boxes of lantana berries from Honolulu to Mr. Jepson, then Government Entomologist in Fiji; a few lantana seed flies *(Agromyza* sp.) emerged from the material received and these were liberated in Suva. Writing in 1916, Mr. Jepson states: "It is satisfactory to record that this fly is now thoroughly established in Fiji, and it is not possible to find lantana within several miles of Suva which does not display evidence of attack by this insect." In the same report he says: "Dissection of the berries also shows that 95% of the berries are attacked by the larvae of this useful fly"; he also adds, "There is unfortunately in Fiji a small parasite *(Chalcididae)* of the lantana seed fly, but it is not sufficiently numerous to affect the propagation of the fly to any serious extent."

A second introduction of Jepson's was *Plaesius javanus* Er., a Histerid predator of the banana borer *(Cosmopolites sordida* Chevr.); in his search for enemies of the sugar-cane borer Mr. Muir discovered this predator in Java, and in 1913 Mr. Jepson successfully transported and liberated 3,500 beetles on seven different banana plantations in Fiji. The beetles were found to be breeding quite freely four months after liberation, but they were then lost sight of and a further supply of beetles was imported by post from Java in 1918. The first evidence of their permanent establishment was obtained in 1921, when Mr. McNamara, of the Inspection Staff of the Department of Agriculture, obtained a specimen of the beetle on Nabalau Estate; its effect on the banana borer position has not yet been definitely ascertained.

The attempt to establish *Ceromasia sphenophori* Vill. (the New Guinea parasite of the sugar-cane borer, *Rhabdocnemis obscura* Boisd.), commenced in 1910 with the colony left by Messrs. Muir and Kershaw at Nausori Mill, where they established an intermediate breeding station when transporting the parasite from New Guinea to Hawaii; great efforts were made to establish the parasite throughout Fiji, and no fewer than twelve of the officers of the Colonial Sugar Refining Company were engaged on the work of breeding the parasite at various centers. In the main sugar growing districts at Lautoka and Rarawai the parasite has failed completely so far and a similar fate attended the efforts to establish it at Labasa; it was believed that the colonies liberated at Nausori had also died out, but in 1920 Mr. Pemberton, who was then at Nausori Mill, discovered that the parasite was actually established. After a thorough examination of the

position towards the end of 1920 the writer was convinced that the parasite had been responsible for a very marked improvement in the borer position at Nausori and a further investigation of the position in 1921 served to strengthen that belief; it is to be hoped that the present satisfactory position at that mill is maintained. In 1909 the percentages of Malabar (Yellow Caledonia) and Badila harvested were almost exactly the same as in 1920 and it may be said that the relative proportions of the two varieties were the same in these two years. It is therefore impossible to attribute to a change of variety the fact that in 1909 the borer damaged stalks amounted to 15% of the total received at the mill, while in 1920 the figure had fallen to 5%. The parasite alone must be given the credit for this great improvement and the writer has no hesitation in claiming that its establishment at Nausori has led to the saving of thousands of pounds annually at that mill. A further determined effort is being made to establish the parasite at Labasa, where borer damage is very serious; at present nothing is being done at Lautoka and Rarawai, where damage is not nearly so extensive. It will be no easy task to establish the parasite at Labasa, but the success at Nausori amply justifies the new attempt. In addition to the original colony brought by Messrs. Muir and Kershaw from New Guinea, colonies have been brought from Hawaii by Mr. North, Dr. Illingworth and the writer; two colonies were also sent to the Vancouver-Fiji Sugar Company.

The writer brought over a large colony of *Scolia manilae* Ashm. from Hawaii in 1917 and liberated some six hundred specimens in the sugar-cane fields of the Sigatoka district where it was hoped it would attack the white grubs of *Adoretus versutus* Har. and *Rhopaea vestita* Arrow.; unfortunately a very heavy flood submerged the whole of the area on which the parasite had been liberated three weeks earlier. Frequent careful examinations have failed to reveal any trace of the Scoliid, but it may eventually be recovered; in captivity it was successfully reared from grubs of the Fijian species.

In 1920 Mr. Simmonds, Acting Government Entomologist in Fiji, visited Tahiti for the purpose of introducing two parasites to assist in the control of the transparent cocoanut scale (*Aspidiotus destructor* Sign.). Reporting on a visit of inspection to the island of Moturiki, where a colony of the imported Tahitian parasites had previously been liberated, he states in June, 1921: "On examination of the affected area the large yellow Chalcid, *Aphelinus chrysomphali*, was found to be well established and doing good work, but the smaller species, *Aspidiotiphagus citrinus*, was not observed except in the pupa state on some of the trees just recently placed there." Continuing his journey to Bureta on the island of Ovalau, he found that *A. citrinus* was "numerous and well established," and he states, "It is satisfactory to find that both parasites are now well established."

The above paragraphs will serve in some measure to indicate the amount of progress achieved in this important branch of economic entomology and they demonstrate how deeply indebted Fiji is to Hawaiian entomologists and their supporters.

Lautoka, Fiji.

A Paper Laying Machine.

The results already obtained indicate that the use of paper as a mulch over the soil above the roots of pineapple plants is destined to become a common practice in the pineapple agriculture of the future.

The adaptation of the paper mulch to pineapple culture has been a very simple matter, requiring only slight deviation from planting methods already

DOTY-WENDT PAPER LAYING MACHINE.

in vogue. A suitable bed of earth is first prepared to receive a row of pineapples; the paper is then applied to this bed in long strips, its edges being held down by a covering of soil; and the pineapple plants are inserted through holes made in the paper at proper intervals.

Up to the present time, the preparation of the bed and the laying of the paper has been done by hand and, consequently, at considerable expense. The machine illustrated herewith prepares the bed, lays the paper and covers its edges in one operation and at very moderate expense. It may be drawn by mules or by a light tractor.

There are three essential parts to this machine, each part performing a definite function:

(1) A plank drag-sled which pulverizes the soil and forms it into a bed of the desired shape to receive the paper;

(2) A flanged roller or spool which is attached to the rear of the sled and shapes the paper over the bed, turning its edges down into the furrows made by the sled runners; and

(3) Shovels or disks which are placed just back of the flanged ends of the roller and which serve to throw the soil against and over the edges of the paper.

The sled may be modified to draw the soil into a bed of any shape desired. The spool should be shaped to conform to the crown of the bed, its barrel being cylindrical if the top of the bed is to be flat and concave if the top of the bed is to be curved.

H. L. L.

The Analysis of Ash in Cane Sugar and Molasses.

By H. A. Cook.

It has long been known that the factor .9 for converting sulfated to carbonated ash, originally adopted for work with beet products and now in use by cane sugar chemists, is greatly in error. There has been considerable agitation within recent years among sugar chemists to do away with the present factor and adopt one that would give more nearly the correct results.

Most of the work that has been done in the comparison between the two methods has been in connection with sugar beet products. In that connection a number of able chemists have protested against the present factor. Among them reference can be made to Violette,[1] who, operating upon a large number of beet sugars of different grades, showed that a deduction of one-fifth is more applicable to all products, excepting high grade sugars, for which a value of three-tenths should be used. Among others in the beet work can be cited the following, who all arrived at about the same conclusion: Dubrunfraut,[2] Girard,[3] Grobert,[4] Boyer,[5] Paszosski,[6] Courtonne,[7] and Mintz.[8] A. Schweizer,[9] referring to work on four molasses, says, "From these figures it is also seen that an assumption of a difference of ten percent between carbonated and sulphated ash is wholly inaccurate, since in the case of the above four molasses the differences are 18, 12, 22 and 22 respectively." Jar. Mekolasek[10] has found that determinations of the ash of beet molasses obtained during the past four campaigns in Bohemia by the two methods show that instead of ten percent, the average deduction works out at 21.44 percent.

In regard to the sugar cane and its products the number of references are comparatively few. J. P. Ogelvie and J. H. Linderfield,[11] working with beet sugars and molasses and also cane sugars and molasses, found that with cane sugars the values were very irregular, varying from 6 to 25 percent, with an average of 14 percent, while with cane molasses the values were reasonably constant, namely, 14 to 21 percent, with an average of 18 percent. Hamakers[12] has calculated from the average composition of cane sugar ash that the deduc-

:ton should be about one-fourth. Weichman[13] has stated that "the subtraction of one-tenth is generally assumed to answer for beet sugars, but is entirely misleading when cane products are being analyzed, because the ash of the latter possesses a composition entirely different from that of the former." Noel Deerr[14] says, "The continued use of the ten percent reduction is an instance of the persistence of a once accepted error in spite of numerous protests."

Considerable work has been done at this Station on the ash of cane sugar. J. M. Reynolds obtained the comparison of the two methods on one hundred samples of cane sugar. At the same time A. Brodie obtained the comparisons on one hundred and fifty samples of cane sugar. These samples represent over 95 percent of the factories in the Islands.

The great majority of these sugars polarized between 96.0 and 97.0. Some varied from 94.5 to 96.0, while some were between 97.0 and 98.0. The ash, in terms of sulfated ash less ten percent, varied from 0.21 to 2.64 percent.

The following table gives the averages of the results obtained by Mr. Brodie and Mr. Reynolds:

	Number Samples	Sulfated Ash	Normal Ash	Average Difference	Factor
Brodie	150	.735	.579	21.22	.788
Reynolds	100	.700	.550	21.43	.786
Average ...	...	.7215	.5687	21.30	.788

The above figures indicate a factor for converting sulfated to carbonated ash of .79. Thirty-one samples had a factor of .79.

From a study of the figures obtained by Mr. Brodie and Mr. Reynolds the following chart can be constructed:

Number of Samples With Factor Below .700	Number of Samples With Factor Between .700 and .750	Number of Samples With Factor Between .750 and .800	Number of Samples With Factor Between .800 and .850	Number of Samples With Factor Between .850 and .900	Number of Samples With Factor Over .900
4	46	98	82	17	3

The results are similar to those of J. P. Ogelvie and J. H. Linderfield in that they show a wide variation in the values for cane sugar.

To determine whether or not there was volatization in burning a carbonated ash a large number of carbonated samples were treated with sulfuric acid and reignited. In all cases the agreement was very close to the result of the sulfated ash and the difference in any case was not large enough to affect the results, showing that the loss by volatization was negligible.

The following gives in tabulated form the results of resulfating the carbonated ash of six sugars and six molasses:

	Sugars				Molasses			
Sample No.	Sulfated Ash	Normal Ash	Factor	Normal Ash After Sulfating	Sulfated Ash	Normal Ash	Factor	Normal Ash After Sulfating
1	0.36	0.27	.75	0.35	11.38	8.37	.74	11.32
2	0.62	0.50	.81	0.65	9.79	6.83	.70	9.76
3	0.51	0.43	.84	0.50	14.09	10.56	.75	13.90
4	0.90	0.72	.80	0.90	13.64	9.93	.73	13.39
5	0.73	0.55	.75	0.73	16.16	12.68	.78	16.11
6	0.77	0.62	.81	0.72	13.38	10.83	.81	13.39
Average..	0.648	0.515	.793	0.65	13.07	9.86	.752	12.98

In a recommendation to the Committee on Revision of Methods of the Hawaiian Chemists' Association, Mr. Lynch gave the results of determinations on nine molasses, comparing the sulfated ash and the carbonated ash. He obtained a factor for conversion of .737. Mr. Lynch also sulfated the normal ash, and in all cases obtained results very close to the sulfated ash.

In view of the fact that so few references were available for cane molasses I have made analysis on over twenty-five different Hawaiian waste molasses. These samples represented molasses from twenty different factories on all the Islands. They were of varying composition. The gravity purity ranged from 27.7 to 42.8. The ash as sulfated less 10 percent varied from 8.42 to 16.19 percent. The determinations were made both for carbonated and sulfated ash.

The method used for sulfated ash was the official method of the H. C. A. The method for the determination of carbonated ash is as follows:

Weigh accurately about three grams of molasses in a weighed platinum dish. Heat carefully over a low flame till all the moisture is evaporated and the gases expelled. Place in a well ventilated muffle at barely perceptible red heat till burned to a white or light grey ash. Care must be taken that the heat is not too high.

The results are as follows:

Factory	Sulfated Ash %	Sulfated Ash Less 10% %	Normal Ash %	Percent Difference Between Sulfated and Normal Ash	Factor Required to Convert Sulfated to Normal Ash
Hakalau	11.32	10.19	8.39	25.9	.741
Honomu	13.36	12.02	9.86	26.2	.738
Hilo	10.89	9.80	8.40	22.9	.771
Onomea	11.46	10.31	8.27	27.8	.722
Pepeekeo	12.41	11.17	9.56	23.0	.770
Kahuku Strike 15-6	11.16	10.04	8.00	28.3	.717
" " 15-1	12.39	11.15	8.98	27.8	.722
" " 15-0	10.61	9.55	7.96	25.0	.750
Kahuku (Regular)	9.77	8.79	7.22	26.1	.739
Pioneer	17.99	16.19	13.74	23.6	.764
Pepeekeo	13.31	11.98	9.88	25.8	.742
Olowalu	11.56	10.40	8.53	26.2	.732
Hawi	13.08	11.77	8.95	31.6	.684
Hawi	13.11	11.80	8.98	31.5	.685
Laupahoehoe	11.16	10.04	8.19	26.6	.734
McBryde	13.20	11.88	10.16	23.0	.770
Hawaiian Sugar	14.18	12.76	10.54	25.7	.743
Union Mill	11.65	10.59	7.90	32.2	.678
Kilauea	13.54	12.19	9.67	28.6	.714
Waimanalo	11.64	10.48	8.95	23.1	.769
Koloa	12.44	11.20	9.05	27.3	.727
Kaeleku	13.74	12.37	9.66	29.7	.703
Niulii	11.14	10.03	8.05	27.7	.723
Lihue	14.69	13.22	10.74	26.9	.731
Oahu	9.36	8.42	7.35	21.5	.785

Average difference 26.6

Average factor .... .734

The factor here shown for molasses is a quite constant value. It would, however, be impossible to adopt a factor that would be exactly accurate for all molasses. It is also evident that the factor now in use, i.e. .9, is far in error. No factor that would be adopted could apply to all molasses on account of the difference in the mineral constituents of the ash. Any result reported as ash would be higher than the true mineral content of the molasses. By ash is meant not only the mineral matter but also the carbon dioxide and carbonates derived from organic material.

While making the foregoing anaylses the question was raised: How close can one check the results of a carbonate ash determination? To answer this question, two sets of comparative analyses were made on twelve different molasses, using the sulfate and carbonate methods. To obtain the comparison under average working conditions the analyses were not made in duplicate, but in different sets on different days.

The results are as follows:

Factory	Sulfated Ash Less 10%			Carbonate Ash		
	First Result	Repeating	Difference	First Result	Repeating	Difference
Pepeekeo	11.89	11.98	0.09	9.88	9.76	0.12
Pioneer	16.07	16.19	0.12	13.74	13.70	0.04
Hawi	11.77	11.85	0.08	8.95	8.95	0.00
Hawi	11.80	11.81	0.01	8.98	9.03	0.05
Olowalu	10.29	10.40	0.11	8.53	8.48	0.05
Laupahoehoe	10.04	10.03	0.01	8.27	8.19	0.08
McBryde	11.88	11.88	0.00	10.18	10.16	0.02
Kilauea	12.33	12.19	0.14	9.67	9.83	0.16
Hawaiian Sugar	12.69	12.76	0.07	10.40	10.54	0.14
Union Mill	10.59	10.51	0.08	7.82	7.95	0.13
Hilo	9.89	9.90	0.01	8.40	8.42	0.02
Hakalau	10.21	10.17	0.04	8.39	8.45	0.06
Pioneer	11.95	11.96	0.01	....	....	....
Average difference	.....	.....	0.059	....	....	0.072

The results show that the carbonate method is just as accurate as the sulfate method.

Considerable objection has been raised to adopting the method of simple incineration because it has been claimed that a clean, well-burned ash is difficult to obtain, and could not be obtained without considerable loss by volatization. I have found it little harder to obtain a good, clean ash. It does take a little longer time than by sulfating in the case of molasses. Mr. Brodie found that with sugars there was very little difference in the time required. It requires a little more attention to details of heating for the carbonated ash. I think that the objections on account of the loss by volatization are answered by the work reported in this paper.

From work done on the two methods of ash determinations the following conclusions and recommendations can be made:

That the factor for conversion in present use, i.e. .9, is far in error.

That for sugars there is quite a wide variation in the factor found for different samples.

That the factor for molasses is a comparatively constant value.

That the loss by volatization in the method by simple incineration is almost negligible.

That the results obtained by burning a carbonated ash check between themselves as well as do those by sulfating.

That for ash determinations in all sugar work the method for carbonated ash be adopted.

That where apparatus is not available and it is not feasible to run a carbonated ash, a factor be adopted that is more consistent with true values. Any factor would necessarily have to be the average figure taken from a large number of determinations. While a factor thus obtained would not be correct in all cases it would be very much closer to the true figure than the one at present in use.

That a factor of .75 could be adopted for molasses.

I would not suggest adopting any definite factor to apply to all sugars, due to the wide variations. Where a factor is desirable it should be determined from the analyses of several samples from each mill. The determinations could be made at the Experiment Station, where facilities are available for both methods.

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Liming Acid Lands.

GROVE FARM EXPERIMENT 8, 1922 CROP.

This experiment, a continuation of the test conducted on the plant cane and reported in Record, Vol XXIII, page 84, deals with the value of sand on Yellow Caledonia cane on mauka land. The cane is first ratoons and the soil is virgin land with an acid reaction.

Coral sand was applied in three quantities, 3¼, 6½ and 9¾ tons per acre, to the plant crop. No additional sand was applied to the ratoon crop, the test on this cane being to determine the residual effect.

On the plant cane there was no appreciable difference in sand and no sand plots The average sand plots gave 40.7 tons of cane and 4.84 tons of sugar per acre, while the no sand plots gave 41.9 tons of cane and 4.98 tons of sugar per acre.

The yields of both cane and sugar were practically the same for the average of all the sand plots and for the no sand plots in this ratoon crop, as the following table shows:

Plots	Treatment	Cane	Q. R.	Sugar
A	3¼ tons sand per acre ..	37.26	8.19	4.55
B	6½ " " " " ..	33.81	8.61	3.93
C	9¾ " " " " ..	33.33	9.49	4.01
X	No sand	35.50	8.49	4.18
	Average sand plots	34.80	....	4.16

Observations on the effect of sand on similar soil at Kilauea would lead one to believe that considerable heavier doses of sand might show some increase in yields, although the increase might not be a profitable one. In some Kilauea tests, where 10 tons of sand showed very little difference in the cane, the spots where the sand was originally dumped and which received several times as large an application, produced far better cane than the surrounding land.

Details of Experiment.

Object:

To determine the residual value of coral sand on mauka virgin land.

Location:

Field 22.

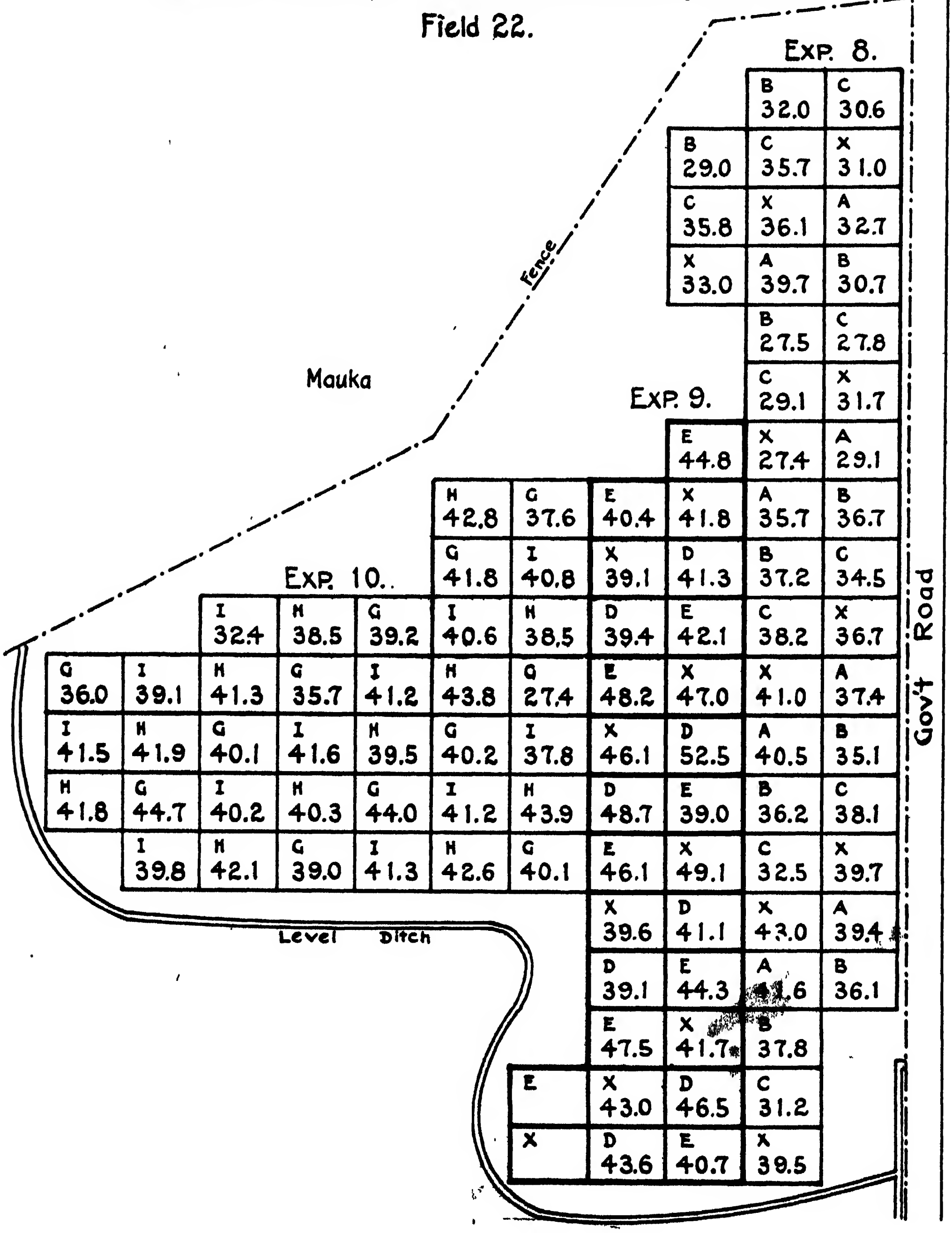
Crop:

Yellow Caledonia cane, first ratoon.

Exp. 8. Sand vs No Sand
Exp. 9. Value of Reverted Phosphate and Amount to Apply
Exp. 10. Value and Amount of Nitrogen

Grove Farm Plantation Experiments 8, 9 & 10, 1922 Crop

Field 22.



Summary of Results (Exp. 8.)

Plots	No. of Plots	Treatment	Yields Per Acre		
			Cane	Q.R.	Sugar
A	9	3¼ Tons Sand Per Acre	37.26	8.19	4.55
B	9	6½ " " " "	33.81	8.61	3.93
C	10	9¾ " " " "	33.33	8.49	4.01
X	10	No Sand	35.50	8.49	4.18

Summary of Results (Exp. 9.)

Plots	No. of Plots	Treatment	Yields Per Acre		
			Cane	Q.R.	Sugar
X	9	No Phosphate	43.39	8.33	5.21
D	8	500* Reverted Phosphate	44.00	8.09	5.43
E	10	1000* " "	43.66	7.76	5.62

Summary of Results (Exp. 10.)

Plots	No. of Plots	Treatment	Yields Per Acre		
			Cane	Q.R.	Sugar
G	12	No Nitrogen	38.80	8.19	4.73
H	12	100* Nitrogen Per Acre	41.40	8.61	4.81
I	12	200* " " "	39.34	8.92	4.41

Layout:

Number of plots = 38.

Size of plots = 1/10 acre (60 x 72.5′).

Plots are composed of 13 straight lines, 4.7′ x 72.5′.

Plots are separated by 3′ roadways running at right angles to rows.

Plan:

Plots	Number of Plots	Treatment			
		Sand per A.	Nitrogen	Phosphate	Mol. Ash
X	9	.....	150 lbs.	500 R. P.	500
A	9	6,500	150 "	500 "	500
B	10	13,000	150 "	500 "	500
C	10	19,500	150 "	500 "	500

Sand applied to plant cane, but none to ratoon crop.

Experiment originally planned and laid out by R. S. Thurston.

Experiment conducted and harvested by J. H. Midkiff.

Juice samples by A. H. Case.

J. H. M.

Mauka Soils Respond to Phosphates.

GROVE FARM EXPERIMENT 9, — 1922 CROP.

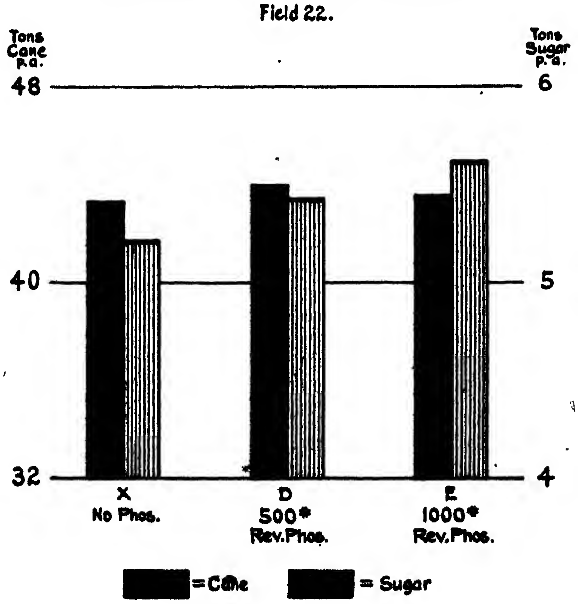
This experiment deals with the value of reverted phosphate on mauka virgin land when applied to ratoon cane of the Yellow Caledonia variety. The plant crop was harvested in June, 1920, and the results reported in Record, Vol. XXIII, page 212.

Reverted phosphate was applied to both the plant and this first ratoon cane at the rate of 500 pounds and 1000 pounds per acre. The check plots received no phosphate on either the plant or the ratoon cane.

The following table shows the results for both the plant and the ratoon crop:

Plots	Treatment	Plant Crop			Ratoon Crop			Average Gain	
		Cane	Q. R.	Sugar	Cane	Q. R.	Sugar	Cane	Sugar
X	No Phosphate.	42.1	8.39	5.02	43.39	8.33	5.21	....	....
D	500 R. P. p. a.	46.5	8.42	5.52	44.00	8.09	5.43	2.51	0.36
E	1000 R. P. p. a.	49.6	8.39	5.91	43.66	7.76	5.62	3.89	0.65

VALUE OF REVERTED PHOSPHATE
AND
AMOUNT TO APPLY
Grove Farm Plantation Exp. 9, 1922 Crop
Field 22.



While the yields of cane and sugar were practically as good from the ratoon as from the plant crop, the gain from the reverted phosphate was not quite as great in the ratoon crop, as a study of the above table will show. The gains

from the phosphate in both the plant and the ratoon crop were, however, profitable.

Details of Experiment.

Object:

1. To determine the value of reverted phosphate on ratoon cane on mauka land.
2. To determine most profitable amount to apply.

Location:

Field 22.

Crop:

Yellow Caledonia first ratoon cane on mauka, virgin soil, unirrigated.

Layout:

Number of plots = 27.
Size of plots = 1/10th acre (60′ x 72.5′).
Plots are composed of 13 straight lines, each 4.7′ x 72.5′.
Plots are separated by 3′ runways at right angles to the rows.

Plan:

Plots	Number of Plots	Treatment		
		Reverted Phosphate	Nitrogen	Molasses Ash
X	9	....	150	500
D	8	500	150	500
E	10	1000	150	500

Phosphate and molasses ash applied first season in one dose. Nitrogen applied in two doses, one first season and one second season.

Experiment originally planned and laid out by R. S. Thurston.
Experiment conducted and harvested by J. H. Midkiff.
Juice analyses by A. H. Case.

J. H. M.

Nitrogen at Grove Farm.

Grove Farm Experiment 10, — 1922 Crop.

This is an experiment to determine the value and the amount of nitrogen to use on ratoon cane on mauka land. It is a continuation of the experiment harvested in 1920 and reported in Record, Vol. XXIII, page 216.

The cane is Yellow Caledonia, first ratoon. The land is a mauka virgin soil and is unirrigated.

The following table shows the harvesting results from the plant crop in 1920 and the first ratoon crop in 1922:

Plots	Nitrogen	Plant Cane Harvested 1920			1922 Ratoon Crop			Average Gain From Nitrogen	
		Cane	Q. R.	Sugar	Cane	Q. R.	Sugar	Cane	Sugar
G	...	38.8	8.93	4.34	38.80	8.19	4.73	....	....
H	100	42.9	9.07	4.72	41.40	8.61	4.81	+ 3.35	+ 0.23
I	200	41.9	9.18	4.57	39.34	8.92	4.41	+ 1.82	— 0.04

The results of both experiments indicate very clearly that, while some nitrogen is needed for maximum crops, heavy applications are decidedly unprofitable, due to the lowering of the purity of the juices. It is probable that an application of even less than 100 pounds of nitrogen on this land would be most profitable.

Experiments upon and experience with this type of mauka soil, where the land is fallowed three years out of every nine, would lead one to believe that the plant cane should have heavy applications of phosphate with very little nitrogen. Lighter applications of phosphate and somewhat more nitrogen to the ratoon cane than to the plant cane seem to give the best results.

Details of Experiment.

Object:

To determine the value of nitrogen and the amount to apply on mauka, acid, virgin land.

Location:

Field 22.

Crop:

Yellow Caledonia cane, first ratoons.

Layout:

Number of plots = 36

Size of plots = 1/10th acre (60′ x 72.5′).

Plots consist of 13 straight lines, each 4.7′ x 72.5′.

Plots separated by 3′ roadways running perpendicular to the furrows.

Plan:

Plots	Number of Plots	Nitrogen	Phosphate	Molasses Ash
G	12	None	500 R. P.	500
H	12	100	500 "	500
I	12	200	500 "	500

Phosphate and molasses ashes applied in one dose first season. Nitrogen applied as nitrate of soda in two equal doses, one first season and one second season.

Experiment originally planned and laid out by R. S. Thurston.

Experiment conducted and harvested by J. H. Midkiff.

Juice analyses by A. H. Case.

J. H. M.

Notes on Foreign Cane Diseases.

Information on two foreign cane diseases was recently received from H. Atherton Lee, Director of Sugar Cane Investigations, Bureau of Science, Manila. In speaking of Uba cane, which shows a strong resistance to Yellow Stripe disease, and which is now being rapidly extended in Porto Rico and other points in the West Indies, he says:

> It grows vigorously during the plant crop, but is extremely susceptible to smut during the ratoon crop, which causes a total loss of the crop. For this reason, we do not believe that Uba cane is apt to succeed in those countries where smut exists.

He states that one plantation in the Philippines has given up Uba cane after growing it for three years, on account of the infestation of smut.

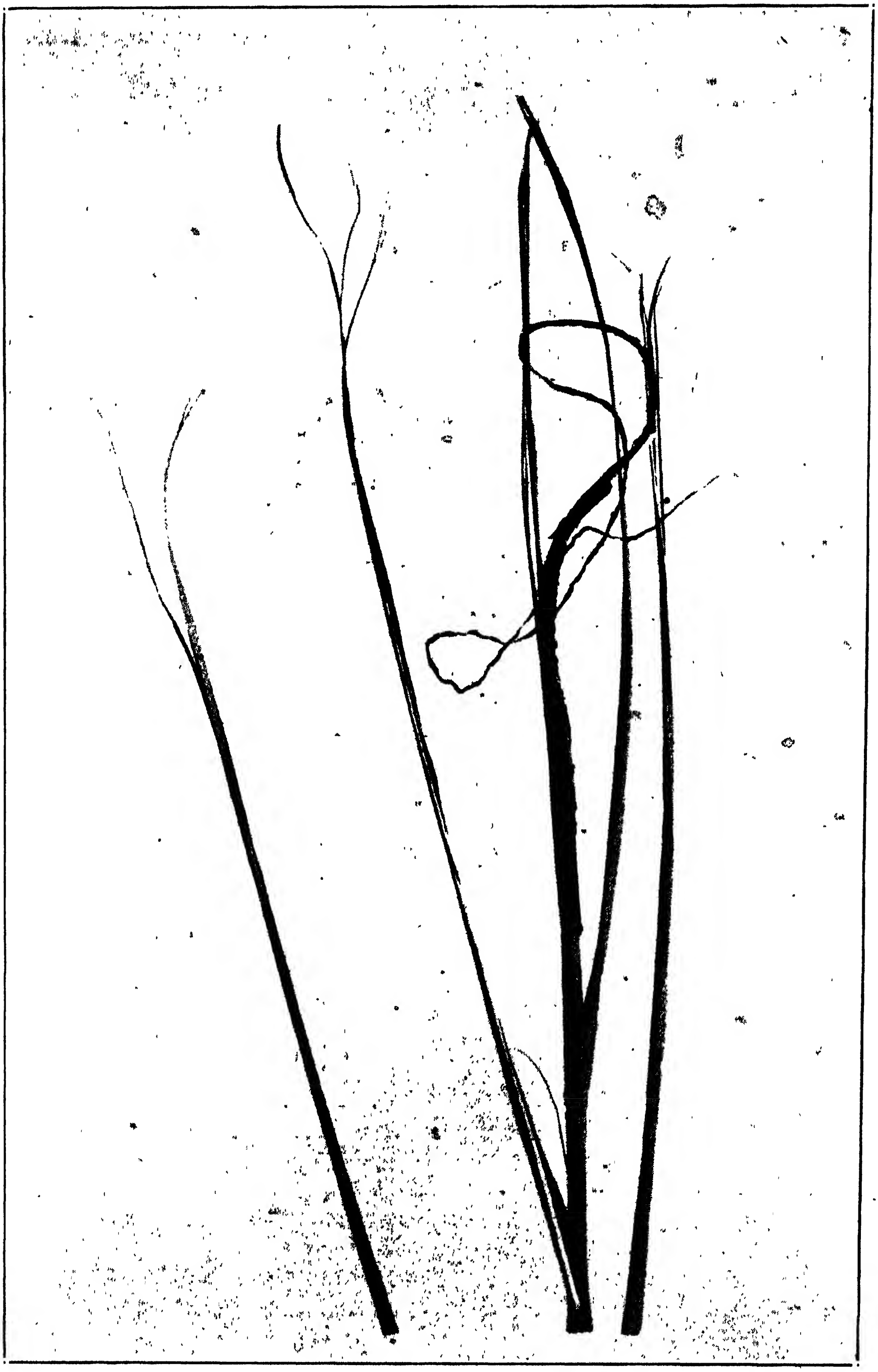
Concerning another malady of sugar cane which it is extremely important to keep out of Hawaii, he writes:

> We are having a good deal of experience with Fiji disease, but largely from discussion with Dr. Lyon and suggestions from Mr. Pemberton in a letter which you gave me, believe that we have it fairly well under control. At the Calamba Sugar Estate, where we organized carefully for seed selection, the disease is now negligible. We are also extending the acreage of Badila cane for seed points as far as possible, since Badila is to some extent resistant. Although we feel now that Fiji disease can be controlled, it costs money to control it, and the point for countries that do not have it is to avoid the handicap of an additional outlay for disease control.

The accompanying photographs illustrating the smut of sugar cane were furnished by Mr. Lee from the files of the Bureau of Science, Manila, P. I.

H. P. A.

At left, healthy cane; at center, two rows of smutted cane; and on right, partially smutted cane; showing the reduction from this disease. The variety in use is Uba cane.



Smut caused by *Ustilago sacchari* on Luzon White sugar cane, July, 1920.

Copy of drawing showing cane plant affected by smut. One-fourth natural size.

'H 400" Seedlings at Waipio.

Waipio Experiment R. — 1922 Crop.

This was an experiment comparing Badila and seven of the so-called "H 400" seedlings with H 109. The test was carried through two crops, one plant and one ratoon.

The plant crop was harvested in September, 1920, at the age of 17 months, while the ratoons were harvested in May, 1922, when 20 months old. The plant received 190 pounds of nitrogen per acre from ammonium sulphate and nitrate of soda in two doses. The ratoons received 310 pounds of nitrogen from nitrate of soda applied in three equal doses, November, 1920; February, 1921, and May, 1921.

In neither crop did any of the varieties equal H 109 in yield. In the plant crop Badila did very well, but as ratoons this variety failed badly when compared with its H 109 checks. This was caused, to some extent, by rat and borer damage.

The yields obtained from the two crops are tabulated as follows:

Variety	Yield per Acre						Average Tons Sugar per Crop
	Plant			First Ratoons			
	Cane	Q. R.	Sugar	Cane	Q. R.	Sugar	
H 109	77.4	7.44	10.40	93.0	7.37	12.62	11.51
H 456	65.1	7.38	8.82	85.9	8.07	10.64	9.73
H 109	71.2	7.44	9.57	95.5	7.37	12.96	11.26
H 463	72.0	8.53	8.44	93.9	8.78	10.69	9.56
H 109	70.9	7.44	9.54	94.8	7.37	12.86	11.20
H 465	60.3	7.88	7.65	84.6	8.04	10.52	9.08
H 109	73.0	7.44	9.82	98.5	7.37	13.36	11.59
H 466	69.7	9.48	7.36	89.9	8.94	10.05	8.70
H 109	62.7	7.44	8.42	87.4	7.37	11.86	10.14
Badila	58.1	6.93	8.39	60.3	8.52	7.08	7.73
H 109	78.1	7.44	10.49	99.1	7.37	13.45	11.97
H 460	70.1	8.02	8.74	80.2	10.09	7.95	8.34
H 109	77.0	7.44	10.35	91.8	7.37	12.46	11.40
H 427	65.5	8.53	7.68	50.1	10.03	5.00	6.34
H 109	75.6	7.44	10.17	107.5	7.37	14.58	12.37
H 464	61.2	7.19	8.52	64.8	9.19	7.05	7.78

In the following table the sugar per acre per month produced by these varieties is given:

Variety	Tons Sugar per Acre per Month	
	Plant	First Ratoon
H 109	0.579	0.647
H 456	0.519	0.532
H 463	0.496	0.534
H 465	0.450	0.526
H 466	0.433	0.502
Badila	0.494	0.354
H 460	0.514	0.397
H 427	0.452	0.250
H 464	0.501	0.352
Average of all except H 109...	0.482	0.421

From the above table we see that H 109 and four varieties responded to increased fertilization and produced sugar faster as ratoons than as plant. The other four varieties could not do that and produced sugar very slowly in the ratoon crop.

We are continuing the three best of the above new varieties — H 456, N 463, H 465 — and have plowed up the others.

The seedlings included in this experiment are those propagated in 1911 to 1914. Some of the H 109 seedlings originated in 1918 and thereabouts, show much greater promise. A few of them show indications of becoming strong competitors of H 109 itself. Thus far these canes have not been extended to the point where large size field comparisons can be made.

J. A. V.

Early Experiments With One-eye Cuttings.

The Planters' Monthly of October, 1900, gave an account of experiments by Walter Maxwell in which different amounts of seed cane were used. The test embraced one-eye cuttings spaced at various intervals.

The results showed "that the quantity of seed planted does not determine the number of canes that are produced."

The report proceeds to say:

"One eye per 6 inches," and "per 12 inches" produces even more canes than "two continuous canes in the row." The lesser number of canes found where "one continuous row" was planted was due to the supreme action of the Rose Bamboo in crowding the Lahaina alongside of it. The number of dead canes found in the Lahaina of that test was greater than elsewhere. As many canes were produced, but they were smothered out. In the last test of "one eye per 18 inches" there were actually fewer canes produced, and the least number died out; so that in that case it is indicated that one eye per 18 inches is too wide to produce a full stand and crop. This observation will be confirmed or corrected by the new series of tests recently begun.

The number of canes produced per row or per acre from using different quantities of seed is a factor. It is not a conclusive factor, however, and in order to judge of the value of thin or thick planting we must also have the weight of cane produced, the quality of the cane juice, and, finally, the actual yield of sugar per acre.

There is very little variation in density, richness, or purity of the juice in the canes grown from different quantities of seed planted. It is observable that the purity of the juices is generally rather low for Hawaiian conditions.

The following data were presented:

Number of Tests	Quantities of Seed Planted	Canes per Row of 107½ Feet
2	Two continuous canes in row ...	382
2	One continuous cane in row	313
2	One eye per 6 inches	387
2	One eye per 12 inches	387
2	One eye per 18 inches	359

These figures show that the quantity of seed planted does not determine the number of canes that are produced.

YIELD OF SUGAR PER ACRE.

Distances of Planting	Cane per Acre	Sucrose in Cane	Sugar per Acre
Two continuous canes in row ...	185,660 lbs.	15.74%	29,212 lbs.
One continuous cane in row.....	193,180 "	15.31%	29,575 "
One eye per 6 inches	194,660 "	15.18%	29,549 "
One eye per 12 inches	195,940 "	15.51%	30,390 "
One eye per 18 inches	175,036 "	15.18%	26,570 "

PLANTING TESTS.

Variety	Mode of Planting	Eyes Planted	Eyes That Grew	Eyes That Died
Lahaina—				
1	Two continuous canes in row ...	2991	1179	1812
2	One continuous cane in row	1490	666	824
3	One eye per 6 inches	645	631	14
4	One eye per 12 inches	321	299	22
5	One eye per 18 inches	208	197	11
Rose Bamboo—				
1	Two continuous canes in row ...	2925	1504	1331
2	One continuous cane in row	1438	865	573
3	One eye per 6 inches	645	623	22
4	One eye per 12 inches	321	308	13
5	One eye per 18 inches	208	200	8

Lap Joints Unsuitable for Longitudinal Seams of Return-tubular Boilers.*

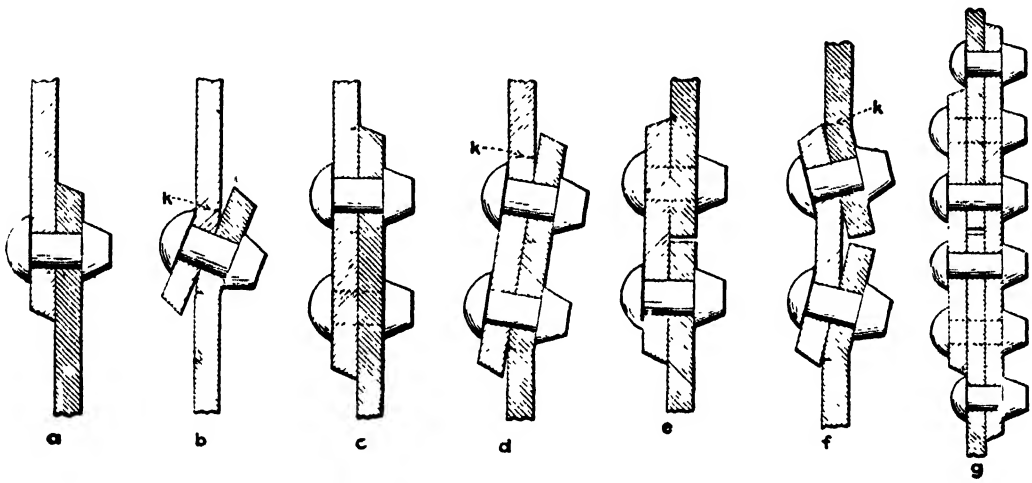
Why are lap joints prohibited and butt joints and double-strap joints required for the longitudinal seams of horizontal return-tubular boilers?

Pressure in a boiler exerts a pull or tension in the metal of the shell. In a lap joint, such as illustrated at *a* and *c*, the plates are eccentric and the stress pulling across the joint has a tendency to draw the plates into line and for the joints to assume the distorted forms shown at *b* and *d*. This bending action is less when the plates are joined with a broader lap, double-riveted, as shown at *c*, and the bending action may be reduced by bending the plates before they are riveted, but the rivets then are exposed to considerable tension as well as shearing stress, in either case the bending action is likely to open the laps and leakage and cracks are likely to occur where the distortion is most severe. The bending action comes into play every time a boiler is fired up, or with a rise of pressure, and the plates are again straightened out when the boiler cools.

With a single-strapped butt joint, such as shown at *e*, all the rivets are in single shear and there also is a tendency to bend the plates and the strap to the form illustrated at *f*.

* From "Power," July 4, 1922.

This continual bending in lap joints and in single-strapped butt joints often causes cracks *(k)* to be formed in the plates beneath the laps, and as these cracks are widened by corrosion and are hidden, they are dangerous. So many boiler failures have been traced to cracks formed in this manner, particularly with lap joints, that these joints have come to be regarded as unfit for longitudinal seams of power boilers or drums that are greater than 36 inches in diameter, and then only if the working pressure is not in excess of 100 pounds per square inch, unless staybolted.



Illustrating method of failure of lap joints. Single and double strapped butt joints.

In a butt and double-strap joint, such as shown at *g*, the plates to be joined lie in line with each other, the joint is built up nearly symmetrical by inside and outside cover plates, and if the main plates and cover plates are curved to true circular form before the joint is riveted, there will be little or no tendency to bending and cracking.

[W. E. S.]

Phosphoric Acid at Kilauea.

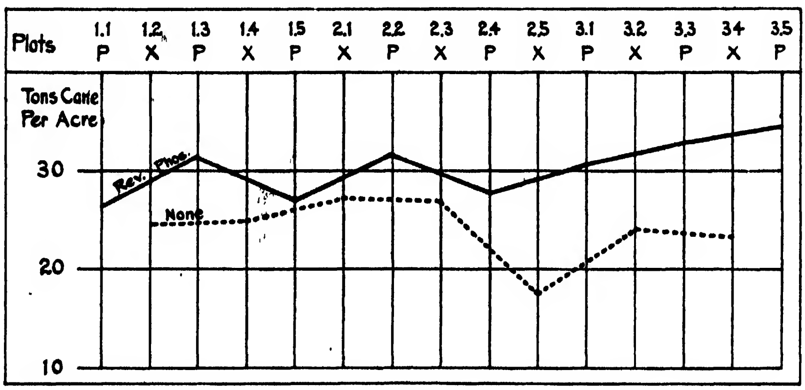
KILAUEA EXPERIMENT 30, — 1922 CROP.

In this experiment reverted phosphate, applied at the rate of 1000 pounds per acre, gave decidedly profitable returns. The cane was Badila plant. The soil is heavy and one of Kilauea's most unproductive types. The field is in the mauka section of the plantation.

REVERTED PHOSPHATE

Kilauea Sugar Plantation Co. Exp. 30, 1922 Crop

Field 37.



The cane was planted in September, 1920. The phosphate was placed in the furrow with the seed. All plots received uniform doses of molasses ashes and nitrogen. About 500 pounds of molasses ashes were applied. The cane received 150 pounds of nitrogen per acre. Seventy-five pounds of nitrogen were applied the first season, in nitrate of potash. A like amount was applied the second season in nitrate of soda. The harvesting results follow:

Plots	Treatment	Cane	Q. R.	Sugar	Gain From Phosphates	
					Cane	Sugar
X	No Phosphate ...	24.19	7.76	3.11	....	....
P	1000 lbs. R. P...	30.35	8.19	3.70	6.16	0.59

The cane in the phosphate plots had tasseled and had more lalas than the no phosphate cane. The fact that the phosphate cane was heavier had caused it to fall down more and it was consequently more rat eaten than the no phosphate cane. Eliminating the rats, there would have been an even greater gain from the phosphates.

This experiment will be carried on to determine the residual effect of the phosphates on the ratoon crop.

Reverted Phosphate

Kilauea S. P. Co. Exp. 30, 1922 Crop

Field 37.

Lihue Side

1.1 P 26.43	2.1 X 27.28	3.1 P 30.80
1.2 X 24.62	2.2 P 31.61	3.2 X 24.17
1.3 P 31.51	2.3 X 27.05	3.3 P 32.94
1.4 X 25.11	2.4 P 27.81	3.4 X 23.35
1.5 P 27.09	2.5 X 17.78	3.5 P 34.58

Hanalei Side

Summary of Results

Plots	Treatment	Yields Per Acre		
		Cane	Q.R.	Sugar
X	No Phosphate	24.19	7.76	3.11
P	1000# Rev. Phos.	30.35	8.19	3.70

Details of Experiment.

Object:

To determine value of reverted phosphate when applied to Badila plant cane on mauka Kilauea land.

Crop:

Badila plant cane.

Location:

Field 37.

Layout:

Number of plots = 15.

Size of plots = 1/10 acre (80.6′ x 54′).

Plots consist of 12 straight lines, each 80.6′ by 4.5′.

Plan:

Plots	Number of Plots	Area	Reverted Phosphate	Molasses Ash	Nitrogen
X	7	0.7 acres	None	500	150
P	8	0.8 "	1000	500	150

Experiment planned and laid out by J. H. Midkiff.

Experiment harvested by J. H. Midkiff.

Chemical analyses by R. Spreckels.

J. H. M.

No Response From Potash.

KILAUEA EXPERIMENT 31, — 1922 CROP.

In this experiment exceptionally heavy doses of molasses ashes were applied to the cane. The lightest dose applied (1000 pounds) is nearly double the ordinary plantation practice. These heavy applications were made because

AMOUNT OF POTASH
Kilauea S.P. Co. Exp. 31, 1922 Crop
Field 37.

Supply Ditch

Mauka

6.1 X 22.18	6.2 B 26.98	6.3 X 27.97
5.1 A 21.03	5.2 X 25.75	5.3 B 26.67
4.1 X 26.55	4.2 A 25.28	4.3 X 25.15
3.1 B 26.17	3.2 X 26.27	3.3 26.75
2.1 X 21.47	2.2 B 27.64	2.3 X 25.26
1.1 A 21.44	1.2 X 24.14	1.3 B 26.62

Makai

Summary of Results

Plots	Treatment	Yields Per Acre		
		Cane	Q.R.	Sugar
X	None	24.97	9.55	2.61
A	1000# Molasses Ash	23.62	9.56	2.47
B	2000# Molasses Ash	26.82	9.61	2.79

cane that had accidentally received about a ton of molasses ashes per acre had, in a previous crop of Yellow Caledonia, evidently made greater gains than the surrounding cane that received about 500 pounds per acre.

The Badila plant cane was about a foot and a half high when the molasses ashes were applied alongside the rows in September, 1920. All the cane received about 1000 pounds of reverted phosphate and approximately 150 pounds of nitrate of soda per acre. With the exception of the molasses ashes, all the cane received identically the same treatment. The soil is very heavy and unproductive and is located in one of the most unfavorable parts of the plantation. The results follow:

Plots	Treatment	Cane	Q. R.	Sugar
X	No molasses ash	24.97	9.55	2.61
A	1000 lbs. molasses ash ...	23.62	9.56	2.47
B	2000 lbs. molasses ash ...	26.82	9.61	2.79

These results do not show that the molasses ashes give any decidedly beneficial results. One thousand pounds per acre gave less cane and sugar than no potash, while 2000 pounds gave a little more cane and sugar. A spot in the same field where piles of molasses ashes were dumped and which received, in those small areas, several tons per acre had better looking cane than the rest of the field.

This experiment will be continued to see if there are any favorable residual results from these large doses.

Details of Experiment.

Object:

To determine the value of heavy doses of molasses ashes when applied to plant cane on one of Kilauea's most mauka, unproductive fields.

Crop:

Badila plant cane.

Location:

Field 37.

Layout:

Number of plots = 18.

Size of plots = 1/10th acre (80.6′ by 54′) consisting of 12 straight lines, each 80.6′ by 4½′.

Plan:

Plots	Number of Plots	Molasses Ash	Raw Rock Phosphate	Nitrate of Soda
X	9	None	1000 lbs. per acre	975
A	4	1000 lbs. per acre	1000 lbs. per acre	975
B	5	2000 lbs. per acre	1000 lbs. per acre	975

Experiment laid out by plantation.
Experiment harvested by J. H. Midkiff.
Chemical analyses by R. Spreckels.

J. H. M.

Studies in Indian Sugar Cane, No. 4.*

[Abridged.]

By C. A. Barber.

TILLERING

In Seedlings.

The tillering or branching of the cane differs considerably according to the variety, and, as the ultimate crop of canes produced is obviously influenced by this character, it is of some importance. Scattered through the literature of the sugarcane, there are to be found many countings of shoots at various stages of growth, as well as the numbers of canes reaped at harvest, and among the records on estates a far greater number probably exist. From these observations the tillering powers of the various canes under cultivation in different circumstances have been fairly accurately determined. But, when we attempt to draw conclusions from this material, we see that the subject has rarely been treated from a scientific point of view, and in almost every case there is an absence of the careful consideration of external factors which might be expected to have influence. We still wait for an exhaustive treatment of the subject with scientific safeguards. The present paper may be regarded as, in some sort, preparatory to such work being undertaken.

It will be well, in the first place, to consider exactly what the term implies. *Tiller* is an old English word, allied to the *telgor* of the Anglo-Saxon, meaning a plant or shoot, and akin to the Dutch *telen*, to breed. At present it is, properly speaking, confined to the mode of branching characteristic of grasses. This consists in the multiplication of shoots, in the young plants, from the lower, short jointed portion of the stem, immediately below the surface of the ground. As we have noted elsewhere, this branching is the main work of the plant during its earlier period of growth. If the seed is sown too deep, one or more elongated internodes bring it to the surface, and then the joints become short and congested and branching commences. Shoots are not only given off by the main stem, but its branches may in their turn give off shoots, until a large number are produced. Branching in the upper, aerial part of the plant is less developed, occurs at a later period of growth and has nothing to do with tillering (cf Percival, *Agricultural Botany*, where the matter is somewhat fully dealt with.)

The factors influencing the amount of tillering in any plant are both inherent and external. Different species and varieties, as well as the seedlings raised in batches from the same parents, differ enormously in this character; but

* From Memoirs of the Department of Agriculture in India, Botanical Series, Vol. X, p. 58.

this difference is often cloaked by a number of surrounding circumstances, all of which seem to be translatable into the amount of food available, and of these, space, light, water, soil, and manure appear to be the most important.

We have followed the early stages of the sugarcane seedling somewhat carefully in a previous section, and it is at once evident that this mode of branching is present in it, and therefore that true tillering occurs in the sugarcane. We usually judge of the vigor of the cane seedlings grown at the Cane-breeding Station, by counting the numbers of canes and shoots at harvest time, and we thus have a certain amount of information as to the tillering capacity of the progeny of different parents.

[The tabulated data of the original article shows the average number of canes for a number of lots of seedlings. For the thick canes the average ranges from 10 to 20, but for the thin canes the average number of sticks is much higher, 30 — 97. Extremes are recorded where there were 110 canes to a seedling stool in one case and 140 in another.

The seedlings are handled under wide spacing, being grown in pits with prepared soil or manure. Sometimes the spacing is 6′ apart, the pits being 2′ each way. Closer spacing is sometimes followed using somewhat smaller pits. Trenching has also been resorted to, the plants being spaced in the trenches so as to give 3760 plants per acre. The wider spacing above recorded furnishes only 1200 plants per acre.]

In Cultivated Canes.

With regard to the ordinary cane varieties planted from sets, it is well known that they differ a good deal in their amount of tillering. Thus the indigenous Indian canes tiller much more freely than the thicker canes of the tropics. This is the common experience of the Cane-breeding Station and, what is more, the descendants of these two classes of cane varieties inherit their parents' characters in this respect. Details regarding the Indian canes are few and far between. Practically the only comparative statement we have come across is one regarding canes grown at Sabour in Bihar.[1] In this statement it is seen that the average number of canes per clump, in the thin Indian varieties grown there is 8 — 16, in the half-thick forms *(Khelia, Striped Bansa, Puri* and *Sukli)* 7 — 8 *(Dahlsunder* 5.5), and in the thick, imported varieties, 4 — 6. It is not possible to deduce accurate acreage numbers from the table, because the details are not given of the space occupied by the clumps investigated. But the plants were put in at about 6000 to the acre, and, assuming that the countings would not be taken where clumps failed, as this would vitiate the results because of different spacing, we get, for the thin canes 48,000 — 96,000 canes per acre, for the half-thick, 42,000 — 48,000 and for the thick, 24,000 — 36,000. The latter figure tallies fairly well with those obtained for the cane varieties grown in the tropics. Numerous data can be obtained for these, and I have selected a few at haphazard from various sources.

[1] Woodhouse, Basu and Taylor. The distinguishing characters of sugarcanes cultivated at Sabour. *Mem. Dept. Agr. Ind., Bot. Ser.,* Vol. VII, No. 2, April, 1915.

Louisiana: *Purple* cane, 35,000.

Java: *Cheribon,* 20,000; *J. 247,* 31,500; *J. 36,* 32,000; *J. 100,* 28,600.

Madras (Godavari delta): *Namalu,* 25,000; *Mogali,* 20,000; *Keli,* 31,000; *Seema,* 22,000; *Yerra,* 37,500, etc.

In almost all of these cases we note that, the thicker the cane, the fewer there are to the acre, and the general observation of this fact has led various writers to suggest that, given similar conditions of soil, climate and treatment, practically the same weight of cane may be reaped per acre whatever the variety may be. This principle appears to be fairly well established, provided that the cane varieties compared belong to the same natural class. A rather striking confirmation of this principle, that thickness and canes per acre are negatively correlated, may be seen in the following table, the details of which have been extracted from Memoir III, where the Saretha and Sunnabile groups of canes are contrasted. These canes were all grown on adjacent plots under the same conditions.

Saretha Group			Sunnabile Group.		
Variety	Canes per Clump	Thickness in cm.	Variety	Canes per Clump	Thickness in cm.
Chin	29	1.5	Kaghze	20	1.6
Saretha (green)......	28	1.7	Bansa	18	1.8
Khari	24	1.8	Sunnabile	17	1.9
Hullu Kabbu	22	1.9	Naanal	15	2.1
Ganda Cheni (poor)..	16	2.0	Dhor (poorly grown).	12	2.2
Average	24	1.8	Average	16	1.9

In this table the varieties of each group (all that were measured) are arranged in order of tillering power and, in the second column, where the relative thickness of the canes is given, the order is seen to be exactly reversed. Too much weight must not, of course, be attached to this interesting result, for the relative differences are by no means proportional, and a comparison of the averages of the two groups is instructive as showing that the class of cane has influence; but a similar result, with many exceptions, is to be found in the longer tables appended, of thickness and tillering power of the varieties of the different groups in the 1917–18 crop on the Cane-breeding Station.

[The table here referred to is not reproduced. It shows a long list of Indian varieties grown under different conditions of cultivation, irrigation, manuring, and spacing. The average number of canes per acre ranges from 49,000 to 151,680. The statement is made that these figures are not from actual counts, but from calculations based on the number of sets planted. Where sets have died out an error is introduced into the estimates as given.]

Tillering and thickness of cane are inherent characters in each variety and group, but we must limit their correlation to the members of the same group. Thus, the Mungo class are among the thickest of the indigenous canes, being

short and bush-like, and their tillering power is very great; on the other hand, the Nargori group contain, on the average, the thinnest Indian canes, and their tillering power is practically the same in the table as that in the Mungo class. Mere thickness cannot therefore be taken as a character from which tillering power can be deduced, but the group character must also be taken into account. In these and other comparisons the thick canes, tropical, are generally taken as one class, because there is at present no classification prepared for them, as for the Indian canes. It is certain that great differences exist, which should be worked out in order to introduce a proper classification in them also. (See, however, Jeswiet's recent papers on this subject, where a series of descriptions of thick canes has been commenced.)

Taking this character of tillering as inherent in the variety, this variation is not surprising, for we have found similar differences to occur in almost every other character of the cane. The comparison of such other characters has been prosecuted for several years, and it is hoped will form the subject of another Memoir shortly. The length and thickness of the cane, the number of joints, the relative length of cane and shoot, the width and length of the leaf, the rate of maturing of the cane and the number of dead leaves adhering to the stem at different periods of growth, all of these characters have been found to vary profoundly, in the same cane, in different localities in India, and we have noted that the locality impresses itself on the plant produced to such an extent, that a survey of the series of measurements will generally enable us to determine in what part of the country the cane has been grown. A large number of deductions could be drawn from this table of tillering, but it is felt that these are foreign to our present purpose and, also, that the figures having been obtained for one year only, require confirmation and extension and it is hoped that this will be done by those in charge of the various farms. It may be noted in passing, however, that one of the most interesting results obtained is the way in which certain varieties seem to be adapted to certain localities, an aspect of the question which will be dealt with in the Memoir proposed.

The following summary table shows that, with the exception of Mungo and the green section of Saretha, the average thickness of the canes in a group varies more or less inversely with the rate of tillering.

Name of Group	Number of Varieties	Average Thickness in cm.	Average Number of Canes per Clump
Mungo	32	2.60	15.10
Nargori	13	1.60	15.10
Saretha (brown)	13	1.62	14.00
Unclassified list	21	1.87	13.60
Sunnabile	22	1.90	12.55
Pansahi	17	1.95	11.00
Saretha (green)	10	1.86	9.50

Deaths During Growth and the Period of Maximum Tillering.

In considering the tillering power of different varieties of canes, founded on the number of canes produced at harvest, it is necessary again to sound a note of warning at the somewhat loose use of the term in general practice. The total number of canes at crop time is not in reality a safe guide to the shooting power, or tillering capacity in its narrower sense, because a large number of shoots die during the life of the plant. This is a necessary result of cultivation, where a tufted grass is forced to grow within narrow limits, so as to obtain as many matured stalks as possible. There is not room for the development of a number of the shoots formed and hence the mortality among them is very considerable. Stubbs in his careful experiments on the *Purple* and *Striped Louisiana* canes in 1894-95, calculated that the deaths of shoots during growth were 58.9 per cent. in 1894 and 53.9 per cent. in 1895. Muller von Czernicki, in Java, counted the number of shoots appearing above ground at varying periods between 60 and 150 days, and showed conclusively that the numbers were far greater at the earlier than the later period. Thus, in *Cheribon* 120 — 180 shoots were counted in different plots at 60 days from planting and only 60 — 70 at 150 days; the figures for *J. 247* were 160 — 240 and 90 — 100, and for *J. 100*, 100 — 170 and 82 — 86 respectively. Struben, in a series of experiments on *J. 247*, found that the better grown plots in the first two or three months gave 300 — 400 shoots per row, in one case the number reaching 415, whereas at eight months all of the rows gave only about 110 shoots. No data are as yet available as to whether Indian canes suffer this great mortality during the earlier period of growth, but there is some reason to suspect, from shoot-counting observations, that it is a much less serious factor than in the thick canes, and further countings have been commenced to settle the question.

Another point to be held in view is the relative rate of germination and tillering in different varieties. This of course does not refer to the effect of cold and drought, as for instance in North India where the early growth is so much slower than in the Indian Peninsula, but only includes comparisons where the conditions are altogether as similar as it is possible to make them. We find that there is a considerable variation in different canes in this respect, as can be readily demonstrated in comparing the Saretha and Sunnabile varieties on the Cane-breeding Station (cf. Mem. III, p. 149). Muller von Czernicki found in his shoot-counting experiments, that *Cheribon* reached its maximum number of shoots in 60 days from planting, *J. 100* at 90 days, while *J. 247*, although having more canes at harvest than either of the others, was slower and later in its earlier stages. In comparing the maximum number of shoots formed in any variety, it is not safe, then, to count the number of shoots in the plots at any one time, but the rate of development must be held in view, so as to get a true maximum for each variety, and from this to deduce the number of deaths occurring. For a time the numbers of shoots formed exceed the deaths and the total numbers steadily rise in the plots, but a period soon supervenes where

there are many more deaths than new formation and, once this period has been reached, there is a continuous and great reduction in total numbers; later on, a sort of equilibrium is reached, when the activity of fresh formation wanes and the shoots are of sufficient vigor and size to be able to maintain themselves and grow to maturity.

Artificial Interference With Tillering.

The great mortality of shoots during growth is obviously of serious import from the crop point of view. Not only is the possible number of canes diminished, but the formation of such numbers of abortive shoots must be a serious drain on the reserves of the plant. Attempts have accordingly been made from time to time to limit the tillering of the sugarcane by artificial means. It is the common practice with many crops to thin the plants out when they have become established, thus assuring a full stand with plenty of room for the development of each plant. This practice is hardly applicable to the present case, which is more analogous to the thinning out of branches in pruning and removing an excessive number of fruits or flowers for the better development of those that remain. Rosenfeld conducted some experiments at Tucuman on the effect of the thinning out of cane shoots on the crop, but found that the results from this procedure were rather adverse than otherwise.[1] These experiments are, however, open to serious criticism and cannot be regarded as demonstrating the inadvisability of the practice of thinning. His experiments were conducted on a single plot of canes, half of which was thinned and the other left intact. There was no control or duplicate plot. He repeated the thinning operation each year on the same plot, where the canes were grown, to first, second, third and fourth ratoons. It would be a mistake to assume that these successive experiments on the same plot were in any way a substitute for proper control plots, in that any fault in the original selection would but be repeated each year. Besides this, it is quite possible that ratoons may behave differently to plant canes in this matter, and also among themselves, whether first ratoons or those of a higher order. No hints are given as to the character of the season in each year, although there are instrinsic evidences that these differed, and it is quite reasonable to suppose that the thinning would have a different value according to the season, and consequent general health and growing of the plants. Lastly, no preliminary experiments appear to have been made at the correct time of thinning. The plot was planted in June, it was thinned in March "where it was thought necessary," "by removing suckers and small canes where there was an abundance of larger better-grown stalks," and the crop was reaped in July. It would seem natural that this late removal of small canes would act prejudicially on the weight of the crop at harvest, and the canes were also naturally, on the average, thicker as well as fewer in the thinned plots. For a decisive result on the effect of thus artificially restraining tillering, the thinning should be carried out sys-

[1] Rosenfeld, A. H. Experiments in thinning out sugarcane rows. *International Sugar Journal*, 1914, p. 220, and 1918, p. 20.

tematically throughout the plots, separate plots should be thinned at different periods of growth, and a reasonable number of controls should be introduced.

In Louisiana, profuse tillering is a matter of some moment because of the shortness of the season. For the best results to be obtained, it should be great in the earlier part and small or absent at the end of the season. This has been very clearly explained by Stubbs,[1] and a further danger in later tillering has been pointed out by him. Shoots developed after July 1 are not likely in Louisiana usually to mature before the cold weather sets in. Furthermore, late tillering and shooting of the aerial buds destroys the evenness of the stand in the ratoons of the following year, as these are (presumably) killed during the cold weather. Stubbs therefore paid very marked attention to the matter for several years, and adopted various methods which, he thought, might regulate the branching of the cane at different periods of growth, his desire being to stimulate the early and restrain late formation of branches. His general conclusions are summed up in the statement that tillering is a natural property of the cane and cannot be prevented. As the result of his experiments he, however, suggests that continued working between the rows without injuring the roots might act as a restraining influence on too late branching.

The earthing up of the cane rows is a well-known practice, both for the purpose of drainage and the provision of suitably prepared nutriment, and for giving the plants a firm hold on the ground when they are tall and stormy weather prevails. It is customary in Java for this operation to be performed at stated intervals, and there appear to be four successive earthings up, during the first four or five months of the plants' growth. This practice, as with all the agricultural operations on the cane field, is doubtless the result of numerous careful experiments during past years. From what we have stated regarding the different phases of growth in grasses, we should naturally assume that the heaping of earth over the base of the cane plant would, by lengthening the period of underground branching, tend to increase the tillering. But it seems to be held by many in Java, that earthing up tends rather to restrain tillering. As, however, the opinions expressed from time to time have been very conflicting, Struben [2] and others have conducted experiments to see if tillering was affected by delaying the earthing up. Struben's general conclusion is that the time of earthing up has little or no effect on the general crop result. In another paper he deals with other matters, such as manuring and spacing, and comes to the same general negative result, and it is worth while drawing attention to the fact that he would almost seem to hold a brief for the non-effect of these various operations, whereas it occurs to us as quite possible that another worker might have come to a somewhat different conclusion on the facts quoted by him. We shall refer to this in more detail later on.

[1] Stubbs, W. C. *Sugarcane*, Vol. 1, Chapter XIV, Suckering of cane.

[2] Struben, W. Vroege of late aanaarding? *Archief. v. d. Suikerind.* in *Ned. Ind.*, Bijblad, 1909, p. 592.

On the Factors Influencing Tillering.

Of all the facts influencing tillering, perhaps the most important is light, but the provision of other needs of the growing plant, such as warmth, moisture, soil constituents and manuring, must also be considered. Lastly, the space available is of immediate effect, because of the interference of the shoots with one another and the varying amount of light and food in all its forms which may be obtainable. It should be obvious that tillering, being an essential characteristic of the growth of the plant, will be assisted by anything that induces a better physical condition.

The Influence of *Light.* We have seen that deeply planted grass seedlings at once set about an attempt at reaching the proper place for tillering, near the surface of the soil. A similar contrivance has been shown to exist in certain young sugarcane seedlings [Vol. XXVI, p. 254, *Record*], but observations have not been recorded as to this habit in deeply planted sugarcane sets. In our dissections, however, we not infrequently meet with what might be termed upright runners, in which long, thin internodes are intercalated between the usual congested short internodes of the base, and doubtless the meaning of this is sometimes the same as that in seedlings, in that thereby the underground part may be placed in the best position for rapid branching, near the soil surface. Tillering cannot take place satisfactorily unless the shoots are able immediately to emerge into the light. But when a certain number of branches have been developed, and the light space so to speak is filled, further shoots are at a disadvantage in that they are overshadowed by their neighbors. This is undoubtedly the cause of the great mortality in cane shoots during the growth of the crop, and it is not easy to see how this perfectly natural effort at producing as many branches as possible can be prevented, if the plant itself has not the power to adapt itself to the conditions. It is fairly certain that this death of shoots is not due to the lack of food supply in the soil, for this can be, and habitually is, supplied to meet all possible needs. Generally speaking, all plants in the light branch more freely than in the shade. Growth in length is repressed in light and a more spreading habit is induced which gives room for more shoots to be developed. As one author has justly argued, of all the food producers on which the plant is dependent, light is the only one over which we have no control. There is a definite amount of light available for each area, and this we cannot increase by any means, whereas air is moving, and water and salts can be applied artificially. We can increase the depth of soil and the amount of water, can improve the physical condition of the soil and add manures as desired, but as soon as the amount of light available is fully occupied, the further branches are shadowed and unhealthy, however many we may by various means cause to be developed. It is a common experience that trees on the outside of a forest, or in free space, are much larger and more uniformly developed than those within the forest, and this is not only due to their greater command of the soil around, but also to the light available, and the same applies to cane plants near the edges of the fields or along the sides of the paths. The problem of obtaining the greatest number of canes per acre is thus seen to be strictly limited by this factor, as

well as by those of cultivation and manuring. Light is perhaps the most important limiting factor as regards tillering.

Moisture also undoubtedly affects tillering, as can be seen by studying the plants along the irrigation channels where they are as closely planted as elsewhere. The frequent advantage of plants so situated should be carefully noted, as suggesting that full use is not always being made of watering facilities. There is still a good deal of work to be done with regard to the effect of the duty of water on the number of canes to be obtained under varying conditions of soil and manuring.

Manuring naturally has its effect on the number of canes produced as well as their individual weight and the richness of their juice. A careful study of this effect has been made by Kilian, who desired to know the best manure to be applied to the three cane varieties which appeared to be suited to the different soils in his estate at Poerwodadi in Java.[1] Although his research was limited to a purely utilitarian problem, the care with which his experiments were conducted renders them valuable from the scientific point of view, and their limited range is of no disadvantage in this respect. The experiments were with *Black Cheribon* and *J. 247*, which were canes growing well in his conditions, and consisted of a series of plots to which were added varying amounts of sulphate of ammonia, superphosphate and cattle manure. Besides studying general yield and other matters, he counted the number of canes at harvest, and this renders his paper of interest to us. Briefly the results were as follows:

In *Black Cheribon*, with the same amount of sulphate of ammonia, increasing doses of superphosphate gave a gradual rise in the weight of cane and of sugar per acre; also there was an increase in the number of canes, but this was less regularly the case. With increasing doses of sulphate of ammonia, the numbers of the canes varied irregularly, whereas the weight of canes and of sugar gradually increased. With the addition of a suitable amount of cattle manure to a moderate amount of both of these artificial manures, there was a distinct rise in the numbers of canes in the plots, as well as weight of cane and of sugar at crop time. The experiments with *J. 247* seem to have been confined to the ammonium sulphate series, and the results were similar to those with *Black Cheribon*.

These experiments were carried out on soils varying from heavy black clay to thin dry loam, and we see that the addition of quantities of suitable manure, especially cattle manure, lead to a distinct increase in the number of canes. It seems probable that similar results would be obtained in other places, once it is determined in what direction the manurial constituents of the soil are lacking. Kilian's results on the numbers of canes are summarized in the following table:

[1] Kilian, J. Bemestings-en plantverband-proeven op de S. F. Kanigoro, oogst 1908–9, *Archief* v. d. *Suikerind.* in *Ned. Ind.*, Vol. XVIII, p. 566. 1910.

NUMBER OF CANES PER BOUW (1¾ acres) WITH DIFFERENT MANURES.

Experiments With Super and Cattle Manure: Black Cheribon.

Manure	Thin Dry Loam	Dry Loam	Heavy Black Clay	
4 pik. sulph. am.	33,011 slight fall *		28,772	
do. + 1 pik. super		38,261		39,204 irregular
do. + 2 pik. super	36,045 rise		34,367 slight rise	
do. + 3 pik. super		40,562		
do. + cattle manure	37.698		36,642	42,865

Experiments With Sulphate of Ammonia and Cattle Manure on Dry Loam.

Manure	J. 247	Cheribon
3 pik. sulph. am.		
4 do.	57,135 irregular	34,559 irregular
5 do.		
6 do.		
4 do. + cattle manure	60,934	35,177

* The words "slight fall," "rise," etc., below an average figure, indicate any changes within the bracketed treatments.

Kobus[1] in an earlier paper (1905) describes the results of his experiments on growing cane uninterruptedly on the same land for a succession of years, with a various assortment of manures designed to take the place of rotation and fallowing. In this series were N, N and P, N and K, N, K and P, and all these with or without the previous addition of Ca. The series is a very full one, as it deals with three different varieties of cane, J. 247, J. 33a and J. 36. He states that the plots were much affected by the weather, there being a severe drought in the earlier part of the season, but that they recovered much better than he had expected. There were, however, many failures in germination, varying from 6.4 per cent. to 12.4 per cent. in the different varieties. Rats invaded the plots and created great havoc, to an extent in some cases of 40 per cent. Lastly, J. 36 suffered from red rot, as this variety is more liable to the disease than the others. Among other data, he obtained the number of canes in each plot, and his general conclusions were that tillering is comparatively

[1] Kobus, J. D. Cultur van suikerriet zonder tusschen-gewassen. *Archief* v. d. *Java Suikerind.* Vol. XIII, 1905, p. 485.

unaffected by manuring. By this we presume that he means rather that the *kind of artificial manure applied,* whether nitrogen, potassium, phosphorus or calcium in their various combinations, has little effect on the number of canes produced per acre. This does not seem to be quite the same position as that taken by Kilian and, for the present, his more special work seems to be more to the point, as it deals rather with the quantity of suitable manure than the kind of manure applied.

Struben,[1] in 1911, asserts that there appear to be no definite experiments

1911, p. 487.

on the effect of manuring on tillering. This seems rather strange, in view of his later quoting from both Kobus and Kilian. He states that he has often noted that very heavy manuring does not affect tillering, although he does not himself experiment in the matter. As we have pointed out above, Struben assumes the attitude that no appreciable alteration is made in tillering by various changes in cultivation, whether spacing, earthing up or manuring, and for this dictum he seems to depend on a generalization of Kobus, made in his 1905 paper, referred to above, that "with a difference of even 10 per cent. in the numbers of canes in a plot, there *may* be a similar outturn of sugar at crop time." This perhaps will throw light on Struben's attitude and, when he asserts that the number of canes is not influenced by manuring, he may mean that, as far as total sugar obtained is concerned, such differences as are noticeable are of little consequence. With this aspect we are at present not concerned, and have little hesitation in concluding that manuring has an influence on tillering, as well as any other means by which the healthiness and vigor of the plant is enhanced.

[1] Struben, W. Uitstoeling. *Archief v. d. Suikerind. in Ned. Ind.*, Vol. XIX, Part 1,

(To be continued.)

Sugar Prices.

96° Centrifugals for the Period

June 16 to September 15, 1922.

Date	Per Pound	Per Ton	Remarks
June 16, 1922	4.61 ¢	$ 92.20	Cubas.
" 19	4.625	92.50	Porto Ricos.
" 20	4.73	94.60	Cubas.
" 22	4.86	97.20	Philippines.
" 26	4.77	95.40	Spot Cubas.
" 27	4.73	94.60	Cubas.
" 30	4.80	96.00	Cubas. Market holiday Friday night until Wednesday morning.
July 5	4.75	95.00	Porto Ricos.
" 6	4.99	99.80	Cubas 4.99, Porto Ricos 5.00, Philippines 4.98.
" 7	5.025	100.50	Cubas 5.05, Porto Ricos 5.00.
" 10	5.00	100.00	Porto Ricos.
" 11	4.99	99.80	Cubas.
" 12	4.93	98.60	Spot Cubas.
" 13	4.905	98.10	Cubas 4.92 and 4.89.
" 14	4.89	97.80	Cubas 4.86 and 4.92.
" 17	5.00	100.00	Porto Ricos.
" 18	5.0533	101.06	Porto Ricos 5.00, Cubas 5.11, Porto Ricos 5.05.
" 19	5.24	104.80	Cubas.
" 21	5.22	104.40	Cubas.
" 25	5.345	106.90	Cubas 5.36 and 5.33.
Aug. 7	5.36	107.20	Spot Cubas.
" 15	5.30	106.00	Spot Cubas.
" 16	5.25	105.00	Spot Cubas.
" 18	5.15	103.00	Spot Cubas.
" 21	5.11	102.20	Spot Cubas.
" 22	5.0575	101.15	Spot Cubas 5.11, 5.08, 5.03, 5.01.
" 23	4.9425	98.85	Spot Cubas 5.01, 4.88, 4.89; Cubas 4.99.
" 24	4.80	96.00	Spot Cubas.
" 28	4.955	99.10	Cubas 4.92 and 4.99.
" 29	4.99	99.80	Cubas.
" 31	5.25	105.00	Spot Cubas 5.25, 5.26; Cubas 5.24.
Sept. 1	5.24	104.80	Cubas.
" 5	5.24	104.80	Spot Cubas.
" 7	4.99	99.80	Cubas. [Beginning Sept. 9, Saturday market days resumed. Basis 4.99, no sales.]
" 14	4.86	97.20	Cubas.
" 15	4.73	94.60	Cubas.